



Sveučilište u Zagrebu
**Fakultet strojarstva i
brodogradnje**



ZAVRŠNI RAD

Voditelj rada:

prof. dr. sc. Željko Šitum

Darije Miloš

Zagreb, 2015.



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SVEUČILIŠTE U ZAGREBU
FAKULTET STROJARSTVA I BRODOGRADNJE



Središnje povjerenstvo za završne i diplomске ispite
Povjerenstvo za završne ispite studija strojarstva za smjerove:
proizvodno inženjerstvo, računalno inženjerstvo, industrijsko inženjerstvo i menadžment, inženjerstvo
materijala i mehatronika i robotika

Sveučilište u Zagrebu Fakultet strojarstva i brodogradnje	
Datum	Prilog
Klasa:	
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ZAVRŠNI ZADATAK

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Naslov rada na
hrvatskom jeziku: **ROBOTSKI MANIPULATOR ZA VELIKE NOSIVOSTI**

Naslov rada na
engleskom jeziku: **ROBOTIC MANIPULATOR FOR LARGE PAYLOADS**

Opis zadatka:

U različitim industrijskim primjenama, kao što su zadaci posluživanja velikih CNC strojeva, sklapanje teških dijelova na automatiziranim montažnim linijama, u ljevaonicama i sličnim zadacima potrebni su manipulatori koji mogu prenositi radne predmete velikih masa. U takvim zadacima robotski manipulatori s električnim pogonom imaju ograničen iznos nosivosti za koje se mogu koristiti, pa primjena hidraulički pogonjenih manipulatora može uspješno odgovoriti postavljenim zahtjevima. U zadatku je potrebno projektirati prototip robotskog manipulatora s hidrauličkim pogonom za velike nosivosti radnih predmeta. Projektirani hidraulički manipulator mora biti usporediv s uobičajeno korištenim manipulatorima koji koriste električne pogone s obzirom na brzinu rada, točnost pozicioniranja, jednostavnost korištenja, ali uz mogućnost ostvarenja znatno veće nosivosti.

U radu je potrebno:


- Analizirati nekoliko izvedbi elektrohidrauličkog robotskog manipulatora i odabrati najpovoljniju kinematičku strukturu s obzirom na radne značajke manipulatora i mogućnost praktične realizacije.
- Izvršiti izbor potrebnih komponenti pogonskog, mehaničkog, mjernog i upravljačkog dijela sustava i dati njihove tehničke specifikacije.
- Dati smjernice i preporuke za praktičnu izradu projektiranog manipulatora.
- Dati procjenu troškova nabavke potrebnih komponenti i izrade robotskog manipulatora.

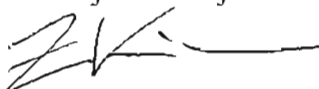
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Prof. dr. sc. Željko Šitum

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Prof. dr. sc. Zoran Kunica

Izjavljujem da sam rad radio samostalno koristeći znanje stečeno tijekom studija i dvanaestogodišnjeg radnog iskustva te navedenu literaturu.

Zahvaljujem mentoru prof.dr.sc. Željku Šitumu.

Darije Miloš

SAŽETAK

Zadatak ovog rada je istražiti mogućnost konstrukcije i izrade te opisati izvedbu manipulatora za veće nosivosti (~ 200 kg). Manipulator će biti izveden u elektro-hidrauličnoj konfiguraciji: elektromotorom pokretana LS-pumpa i izvršni članovi: hidromotor za prvi rotacijski član i dva hidraulična cilindra za osiguravanje tražene nosivosti.

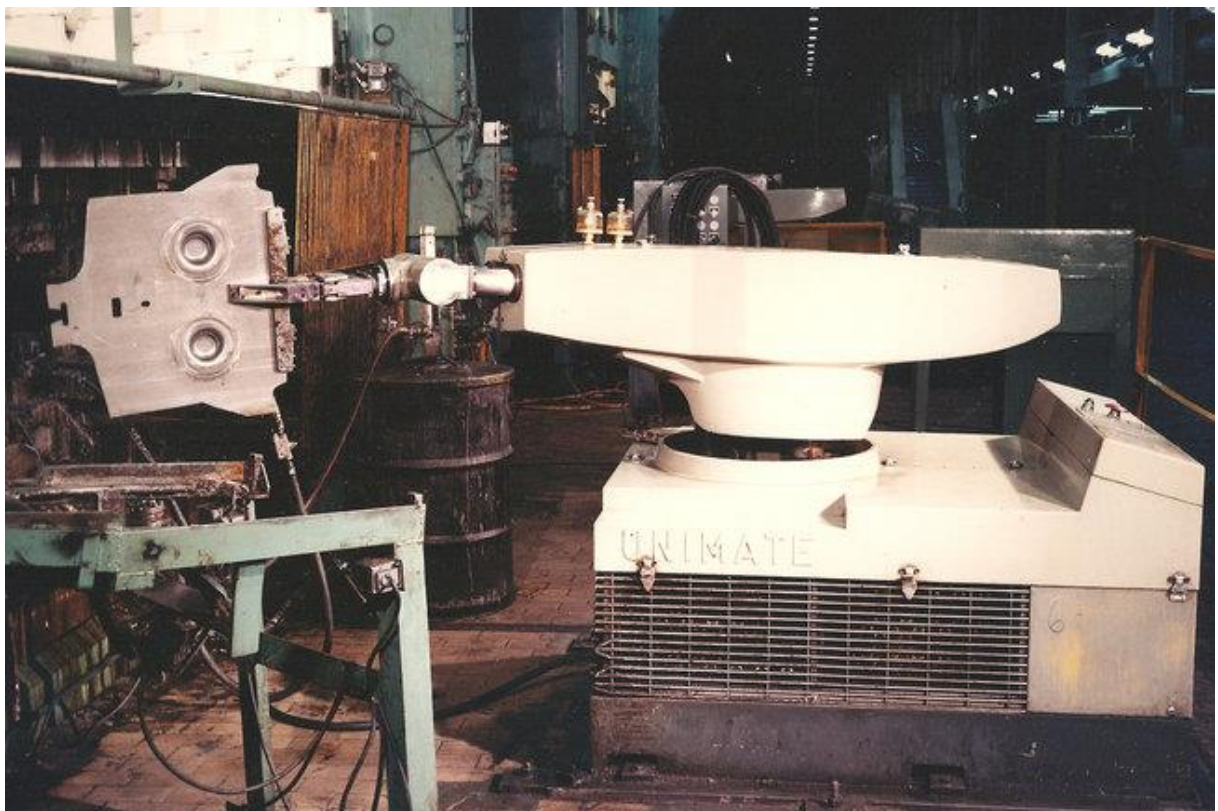
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1. Uvod

Razvojem industrije, kroz povijest su nastajala područja industrijske proizvodnje sa sve složenijim proizvodnim postupcima; na drugoj strani se javljala potreba za manipulacijom sve težih i većih obradaka. Kako bi olakšali i ubrzali postupke izrade i manipulacije, inženjeri su ručni rad zamjenjivali manipulatorima koji su te poslove mogli obavljati brže, preciznije, bez umora, s mogućnošću prenošenja teških obradaka. Prvi manipulator primijenjen u industrijskoj proizvodnji bio je UNIMATE (1961.) [1], [2] u General Motorsu (SAD) za manipulaciju odljevaka, slika 1. Manipulator je primijenjen u vrlo teškom okolišu za čovjeka: vrućina, opasna isparavanja te masivni i vrući odljevci.



Slika 1. UNIMATE

Nakon ovog manipulatora proizvedene su razne izvedbe manipulatora za različite namjene koje se danas masovno koriste u autoindustriji pri zavarivanju i montaži; u elektroničkoj industriji za montažu; u ljevarstvu i kovanju za manipulaciju teškim obradcima; nuklearnim postrojenjima – rad u opasnoj okolini; medicini...

U ovom radu analizira se manipulator za velike nosivosti koji može biti primijenjen kao manipulator za posluživanje npr. CNC stroja: tokarilice ili glodalice.

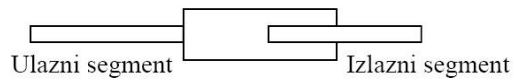
2. Osnovne strukture manipulatora

Manipulatori su u industrijskim primjenama najčešće pričvršćeni za podlogu, a sastoje se od tijela i ruke na čijem je kraju zglob ili prihvatnica kojom se hvata objekt manipulacije.

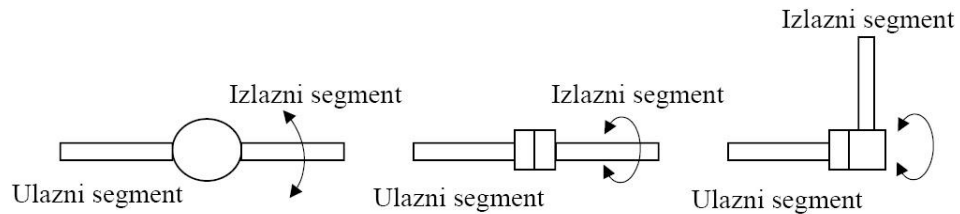
Glavni dijelovi manipulatora su:

1. nosiva mehanička struktura: sastoji se od niza segmenata povezanih zglobovima koji mogu biti:

- a) translacijski (T)



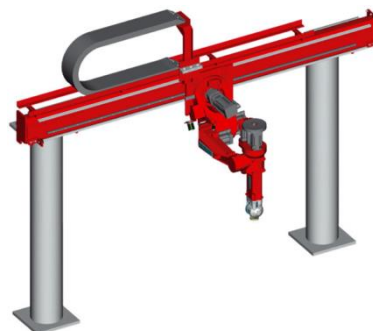
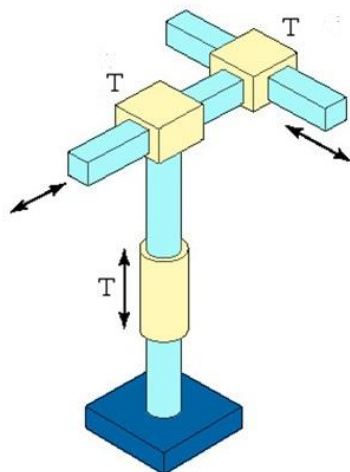
- b) rotacijski (R)



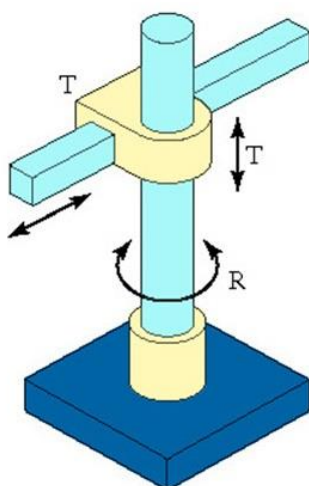
2. pogoni (aktuatori): omogućuju manipulatoru željeno kretanje ili postavljanje u traženi položaj; mogu biti električni, pneumatski i hidraulični,
3. senzori: mjere trenutni položaj osi manipulatora,
4. upravljanje: računalo koje omogućuje upravljanje i nadzor manipulatora.

Najčešće konfiguracije manipulatora su [3] :

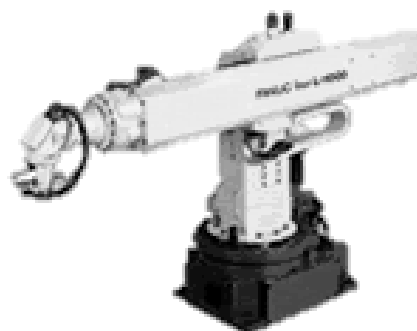
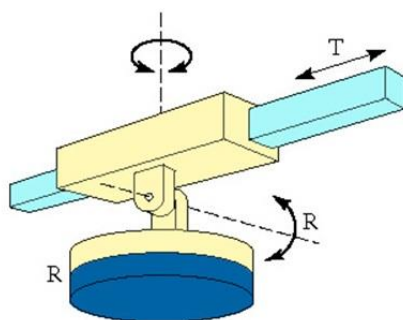
a) pravokutna (Kartezijeva): TTT



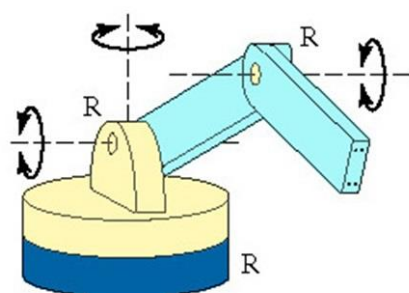
b) cilindrična: RTT



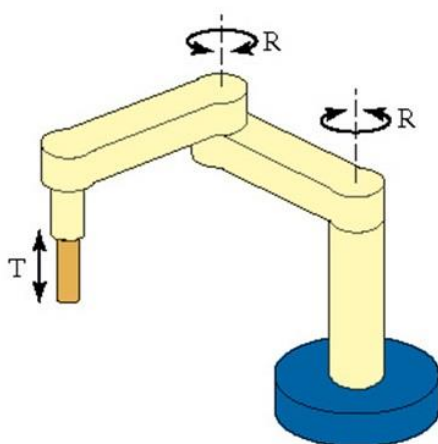
c) sferna: RRT



d) rotacijska: RRR



e) SCARA: RRT



Za daljnje razmatranje odabrana je sferna konfiguracija RRT koja ima dva rotacijska zgloba i jedan translacijski zglob.

Ovakva konfiguracija je rjeđa u praktičnoj primjeni, no u ovom slučaju odabrana je zbog želje za prikazom različitih izvršnih komponenti na jednom uređaju (rotacija pomoću hidromotora i hidrauličnog cilindra, translacija pomoću dvoradnog teleskopskog cilindra). Kao odlike konfiguracije moguće je navesti mali momenti inercije i dobru fleksibilnost. U nekim radovima [4] moguće je naći da je RRT konfiguracija povoljnija sa stanovišta ukupnog utroška energije i vršnih momenata aktuatora.

Na kraju ruke potrebno je montirati prihvaticu kojom se obradak može uhvatiti i premjestiti.

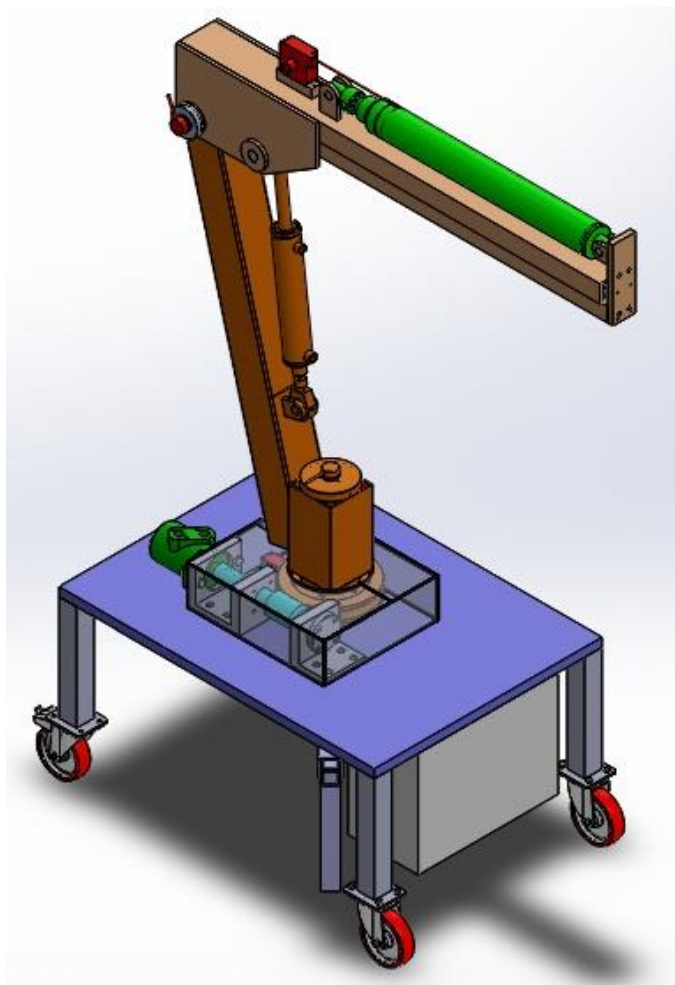
Ovakvu konfiguraciju imao je i prvi industrijski robot UNIMATE, a slična izvedba česta je kod mobilnih manipulatora smještenih na dostavnim vozilima i kamionima, slika 2.



Slika 2: Mobilni manipulator proizvođača FASSI

3. Konstrukcija i izbor komponenti

Kao što je vidljivo iz prethodnog poglavlja, odabrana je sferna konfiguracija manipulatora s dvije rotacijske i jednom translacijskom osi, slika 3. Manipulator se nalazi na osnovnoj ploči koja je oslonjena na noge s kotačima koji omogućavaju mobilnost manipulatora, a za radni položaj predviđeno je oslanjanje na podesive noge s čvrstim osloncima.



Slika 3: Elektrohidraulički robotski manipulator - EHROM

3.1. Konstrukcijski elementi

Manipulator je konstrukcijski podijeljen na tri dijela, to su:

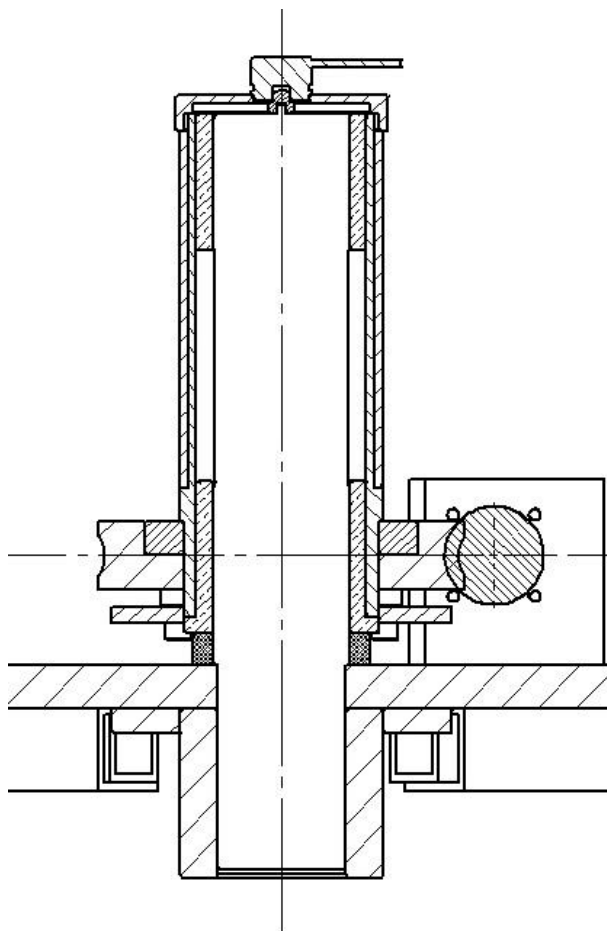
1. osnovna ploča s nogama, središnjim stupom i hidromotorom s pužnim prijenosom,
2. stupna konstrukcija s pužnim kolom i podiznim cilindrom,
3. translacijska konzola s teleskopskim cilindrom i prihvatnicom.

Ovi elementi povezani su međusobno u dva rotacijska zgloba. Treći stupanj slobode je translacija pokretnog dijela konzole.

Manipulator je zamišljen kao nastavno pomagalo pa je glavna konstrukcijska ideja bila pristupačnost i vidljivost svih elemenata koji sudjeluju u gibanju manipulatora. Istodobno se vodilo računa o dostupnosti standardnih konstrukcijskih elemenata: profili, kvadratne cijevi, ležajevi, hidraulične komponente, kako bi trošak izrade bio što manji. Mogućnost obrade pozicija prilagođena je strojnom parku tvrtke Hidraulika Kutina d.d.

3.1.1. Rotacija postolja robota

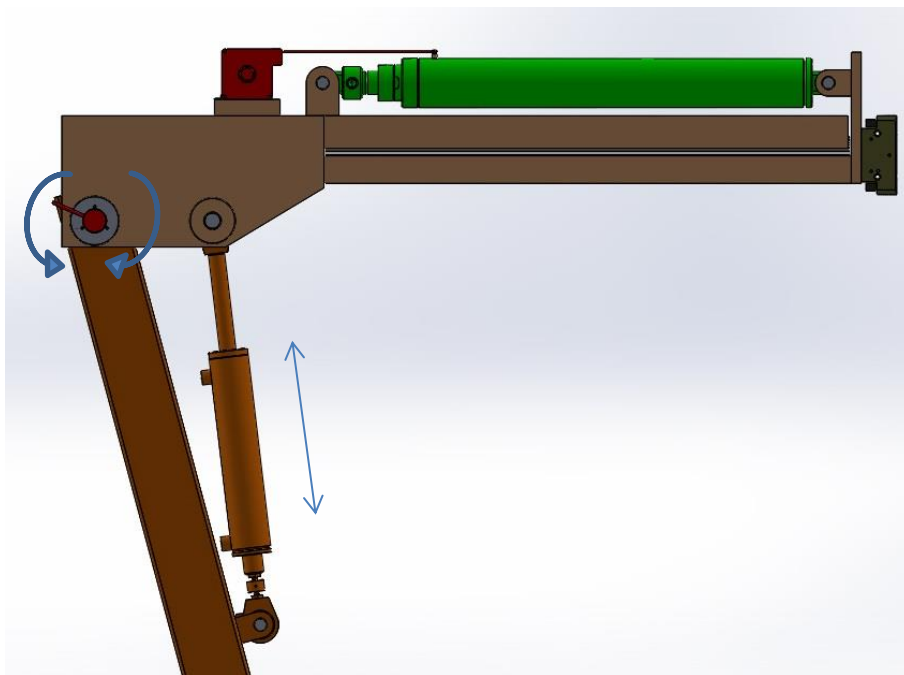
Prvi zglob je rotacija stupne konstrukcije oko središnje osovine. Uležištenje je izvedeno u aksijalnom i radijalnom smjeru. Aksijalno je ugrađen aksijalni kuglični ležaj FAG 51116. Radijalno uležištenje je izvedeno s dva klizna ležaja od bronce koji kližu po osovini.



Slika 4: Uležištenje prve okretne osi

3.1.2. Rotacija translacijske konzole oko osovine na stupu

Drugi stupanj slobode je rotacija translacijske konzole oko osovine na stupu. Rotaciju omogućuje dvoradni hidraulični cilindar, koji je s donje strane učvršćen na stupnu konstrukciju, a gore na nepokretni dio konzole, slika 5.

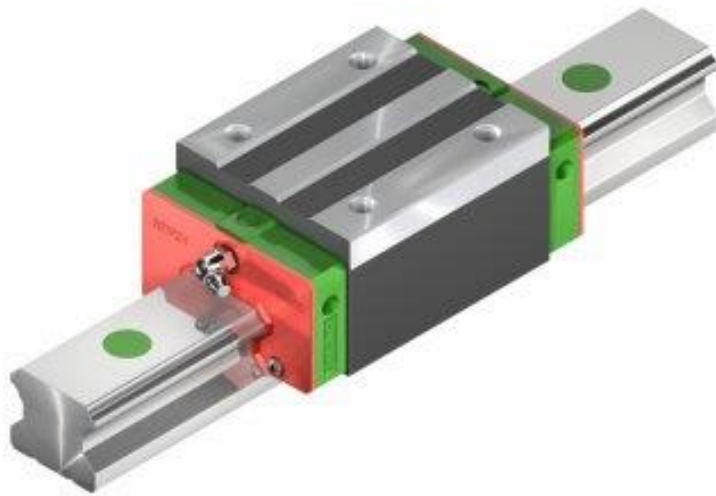


Slika 5: Drugi rotacijski zglobovi

Kut rotacije iznosi 82° , što omogućava zahvat nekog elementa prihvatnicom s poda, a zatim podizanje na visinu 2480 mm.

3.1.3. Translacija konzole

Treći stupanj slobode je translacija pokretnog dijela konzole koju omogućuje dvoradni teleskopski hidraulični cilindar opisan u točki 3.2.5. Zglob je izveden pomoću vodicice pravokutnog presjeka s kugličnim vođenjem. Ovakve vodicice koriste se na obradnim centrima, alatnim strojevima, automatskoj opremi. Vodicica HGH35HA, slika 5, omogućuje glatko i ravnomjerno gibanje pomičnog dijela konzole. Sastoji se od statičnog dijela (vagona) i pomičnog dijela (tračnice) dužine 1,2 m.



Slika 6: Linearna vodicica

Prilog 1: Linerana vodicica HGH 35 HA

3.2. Pogonski elementi manipulatora

Pogon manipulatora sastoji se od pumpe [7] , hidroagregata, hidromotora, podiznog i teleskopskog hidrauličnog cilindra.

3.2.1. Pumpa

Za pogon manipulatora odabrana je klipna pumpa tvrtke Parker oznake PV023R1K1T1NMFC s LS (eng. Load sensing) funkcijom. Pojašnjenje oznake moguće je naći u prilogu o pumpi na str. 6.



Slika 7: LS klipna pumpa

Ova pumpa odabrana je prema potrebnom protoku (glavni potrošač je hidromotor), a LS izvedba zbog energetske učinkovitosti sustava u kombinaciji s proporcionalnim razvodnikom PVG 32 s LS povratnom vezom.

Osnovne karakteristike pumpe:

- klipno-aksijalna pumpa s nagibnom pločom
- volumen po okretaju: $23 \text{ cm}^3/\text{okr.}$
- protok pri 1500 o/min: 34,5 l/min
- maksimalan broj okretaja: 300 min^{-1}
- ostale karakteristike u prilogu pumpa

Prilog 2: Pumpa PV 23

3.2.2. Hidroagregat

Hidroagregat je pogonska cjelina sastavljena od elektromotora snage __, LS pumpe PV32, bloka sa sigurnosnim ventilom i spremnika ulja volumena ____l . Smješten je ispod osnovne ploče kako bi manipulator bio kompaktniji.

Na žalost do završetka pisanja rada hidroagregat nije kompletiran.

3.2.3. Elektroormar

Dio osnovne opreme manipulatora je i elektroormar u kojem se nalaze sve električne komponente sustava.

3.2.4. Hidromotor

Za odabir hidromotora potrebno je prethodno odabrati način pogona prve osi. Kao rješenje odabran je pužni prijenos s pužnim vijkom i kolom.

3.2.4.1. Odabir pužnog prijenosa

Zupčanički par odabran je prema unutrašnjem promjeru zupčastog vijenca koji je bilo moguće ugraditi na stup oko kojeg se okreće manipulator [5]. Maksimalna veličina bila je $\varnothing 115$ mm. Prema tome je odabrana vanjska veličina 215 mm prema DIN 3975 / 3976, za osni razmak 125 mm. S pužnim kolom uparen je pužni vijak promjera 50 mm. Odabran je modul $m=5$ i prijenosni omjer $i=40:1$. Naknadno je s proizvođačem dogovorena izmjena modula zbog dostupnosti alata za izradu u modul $m=4$, tako da je prijenosni omjer $i=50:1$.

Podaci zupčastog vijenca:

- prijenosni omjer: $i=50:1$
- modul: $m=4$
- broj zubi: $z=50$
- zahvatni promjer: $D_e=212$ mm
- materijal: SL 25

Podaci pužnog vijka:

- prijenosni omjer: $i=50:1$
- modul: $m=4$
- broj zubi: $z=1$
- zahvatni promjer: $d_m=58$ mm
- materijal: Č 4320, cementirano: 0,6-0,8 mm; kaljeno 58-60 HRC

Prilog 3: Pužni vijak i kolo

Pužni vijak je uležišten u dva aksijalno radijalna ležaja FAG 7205-B.

Prilog 4: FAG X-life

3.2.4.2. Odabir hidromotora

- projektirana kutna brzina: $\omega = 120 \text{ }^\circ/\text{s} \approx 0,33 \text{ okr/s} \approx 20 \text{ okr/min}$
- prijenosni omjer: $i=50:1$
- broj okretaja pužnog kola: $\omega = 20 \text{ okr/min}$
- potreban maksimalni broj okretaja hidromotora: $\omega = 20 * 50 = 1000 \text{ okr/min}$
- odabran je hidro motor M+S Hydraulic EPM 50, slika8.



Slika 8: Hidromotor

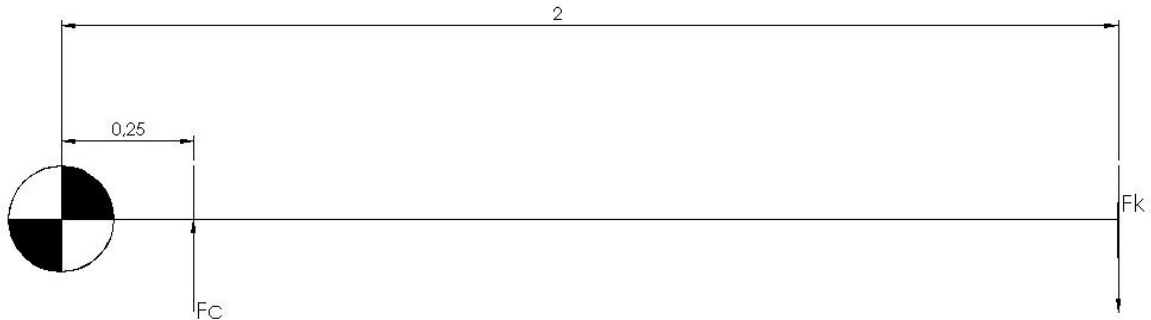
Karakteristike hidromotora:

- volumena: $49,5 \text{ cm}^3/\text{okr}$
- maksimalna brzina: 1210 okr/min
- maksimalni okretni moment: 94 Nm
- maksimalni radni tlak: 140 bar
- maksimalni protok: 60 l/min.
- ostale karakteristike u prilogu

Prilog 5: Hidromotor EPM 50

3.2.5. Podizni hidraulični cilindar

Za odabir hidrauličnog cilindra osnovna veličina je zadana nosivost manipulatora koja iznosi 200 kg na kraju ruke, slika 9.



Slika 9: Plan sila

$$F_c \times 0,25 = F_k \times 2 \quad (3.1.)$$

$$F_c = F_k \times \frac{2}{0,25} = 2kN \times \frac{2}{0,25} = 16kN (\cong 1,6t) \quad (3.2.)$$

$$F_c = p \times A_c \quad (3.3.)$$

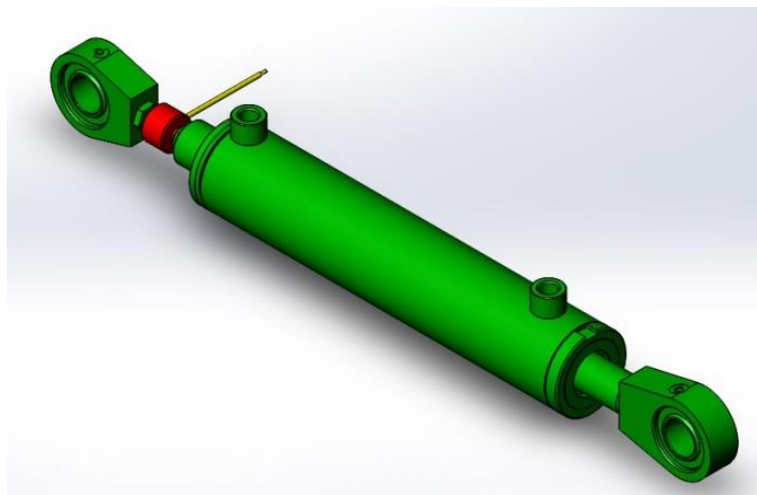
$$A_c = \frac{F_c}{p} = \frac{16000}{100 \times 10^5} = 1,6 \times 10^{-3} m^2 \quad (3.4.)$$

$$D_c = \sqrt{\frac{4 \times A}{\pi}} = \sqrt{\frac{4 \times 1,6 \times 10^{-3}}{\pi}} = 0,045 m = 45 mm \quad (3.5.)$$

- odabrana je prva veća standardna veličina hidrauličnog cilindra $D_c=50mm$

Karakteristike dvoradnog hidrauličnog cilindra, slika10.

- cijev: Ø50 / Ø60
- klipnjača: Ø25
- hod: 210 mm
- cilindri sličnih dimenzija standardno se nalaze u proizvodnom programu Hidraulike Kutine d.d.
- na krajevima cilindra ugrađeni su sferni G-ležajevi kako bi na senzor sile djelovala samo aksijalna sila



Slika 10: Podizni dvoradni hidraulični cilindar sa senzorom sile

3.2.6. Teleskopski dvoradni hidraulični cilindar

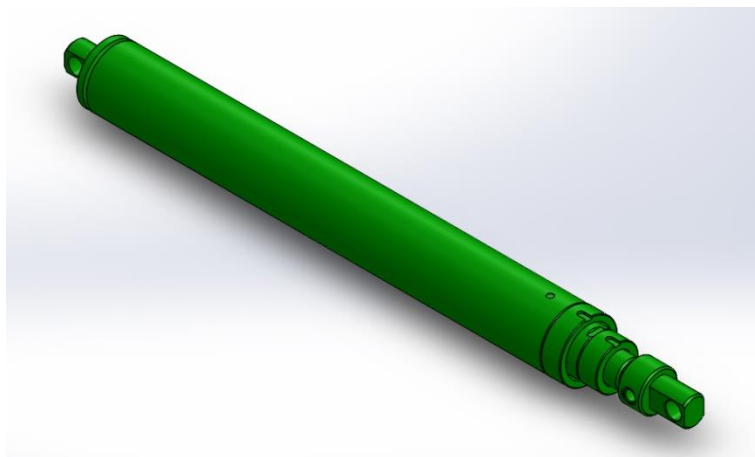
Odabir dvoradnog teleskopskog hidrauličnog cilindra bio je kompromis kako bi se studentima uz ostale hidraulične komponente mogao prikazati i on kao mogući element u hidraulici. Veličina cilindra je odabrana uz pomoć kataloga za standardne veličine elemenata cilindra i dostupnih materijala na skladištu Hidraulike Kutina d.d.

- minimalana povlačna sila pri uvlačenju:

$$A_{min} = \sqrt{\frac{\pi}{4}(D_v^2 - D_u^2)} = \sqrt{\frac{\pi}{4}(0,045^2 - 0,035^2)} = 6,283 \times 10^{-4} mm^2 \quad (3.6.)$$

$$F_u = p \times A_{min} = 100 \times 10^5 \times 6.283 \times 10^{-4} = 6.283 \text{ kN } (\cong 628 \text{ kg}) \quad (3.7.)$$

- izračunata sila zadovoljava jer maksimalan teret iznosi 200 kg



Slika 11: Dvoradni teleskopski hidraulični cilindar

Karakteristike dvoradnog teleskopskog hidrauličnog cilindra, slika 11.

- vanjska cijev: Ø63H8 / Ø75
- srednja cijev: Ø45H8 / Ø55f7
- unutrašnja cijev: Ø25 / Ø35f7
- hod: 1000 mm
- priključci se nalaze na ušici unutrašnje cijevi kako bi bio moguć rad dvoradnog teleskopskog cilindra, slika 11.

3.3. Upravljački dio manipulatora

Upravljački dio manipulatora sastoji se od razvodnog ventila i upravljačke ručice - joysticka, predviđena je i mogućnost spajanja manipulatora na računalo.

3.3.1. Razvodni ventil

Kako bi simultano mogli upravljati sa sve 3 osi odabran je proporcionalni razvodnik Danfoss PVG32, oznake komponenti u

Prilog 6: Razvodnik PVG 32 specifikacija.

Razvodnik je sastavljen od 4 razvodna segmenta te priključne i završne ploče, slika 12. Razvodnikom je moguće upravljati pomoću poluga i daljinski pomoću upravljača Joystick Prof-1.



Slika 12: Razvodnik PVG 32

Osnovne prednosti ovog razvodnika:

- protok ulja u segmentu neovisan je o tlaku u tom segmentu
- protok ulja u segmentu neovisan je o tlaku u susjednim segmentima
- dobra svojstva regulacije
- utječe na energetske učinkovitost sustava
- lagan
- kompaktne konstrukcije i lagane ugradnje.

Karakteristike razvodnika:

- radni tlak: 0-160 bar
- protok: 10 l/min

Prilog 7: Razvodnik PVG 32-4

3.3.2. Joystick

Razvodnikom je moguće upravljati polugama na samom razvodniku, ali to nije praktično zbog opasnosti za rukovatelja zbog moguće kolizije s rukom manipulatora. Da bi se izbjegla ta opasnost i poboljšala mogućnost obavljanja zadanih radnji s rukom manipulatora na razvodnik se priključuje daljinski upravljač. Za tu svrhu odabran je proizvod tvrtke Sauer Danfoss Joystick Prof-1, slika 13.



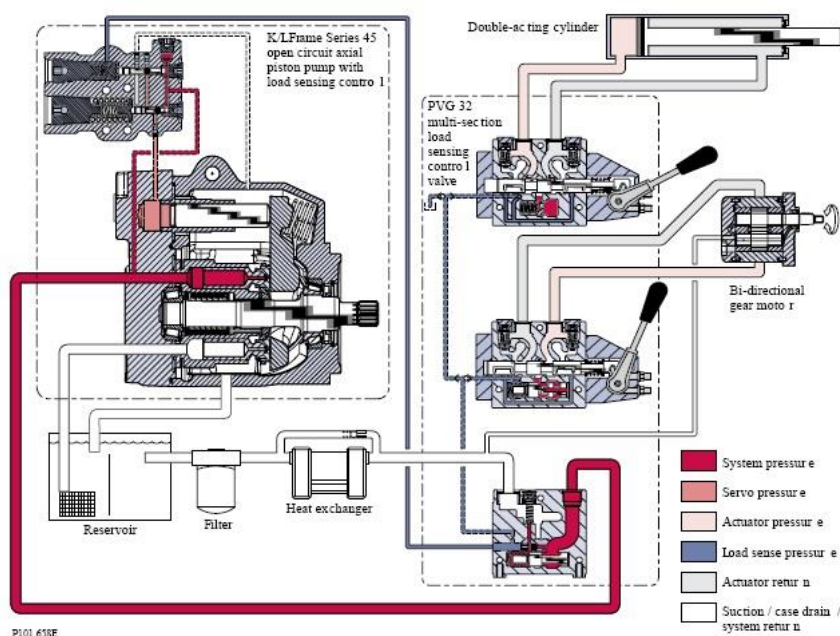
Slika 13: Ručica daljinskog upravljača

Upravljač je ergonomski oblikovan za učestalu upotrebu u radnim strojevima i ostaloj profesionalnoj opremi. Moguće je istodobno upravljati s tri osi pomoću dva integrirana proporcionalna prekidača u X i Y smjeru i kotačića u ručici za treću os. Dostupni su i prekidači za dodatne funkcije.

Prilog 8: Joystick PROF 1

3.4. Regulacija rada pumpe impulsom tlaka

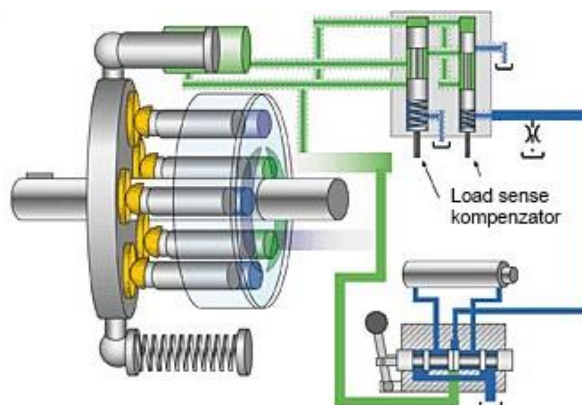
Regulacija rada pumpe impulsom tlaka (eng. Load sensing - LS) [8], [9], ima funkciju prilagođavanja tlaka i protoka pumpe trenutnom opterećenju, slika 14. U sustav su spojeni pumpa i hidraulični razvodnik s kojeg ide povratna veza na pumpu.



Slika 14: Shema rada LS sustava

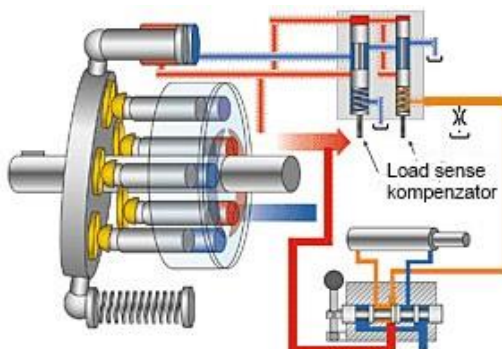
Rezultat ovakvog spoja je sustav s malim gubitkom energije, uz istodobno vrlo precizno upravljanje traženim hidrauličkim funkcijama. Osnovni smisao ove kombinacije je mogućnost uštede energije jer LS sustav ne dopušta pumpi rad na maksimalnom tlaku, nego upravo onom koji je dovoljan za pokretanje izvršnih elemenata.

Kada u sustavu nije potreban tlak za izvršavanje neke funkcije, nagibna ploča u pumpi je u takvom položaju da pumpa daje samo tlak potreban za održavanje sustava, slika 15.



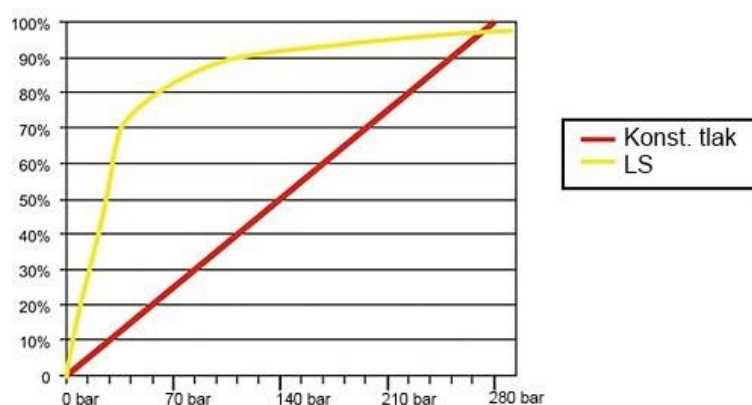
Slika 15: Neopterećeni LS sustav

Pojavljivanjem potrebe za tlakom i protokom, što pumpa dobiva kao ulazni signal s razvodnika, nagibna ploča se zakreće i pumpa daje potreban tlak u sustav, slika 16.



Slika 16: Opterećeni LS sustav

Na donjem grafu, slika 17, prikazan je odnos učinkovitosti sustava s konstantnim tlakom i LS sustava. Može se vidjeti da je LS sustav do tlaka od 260 bara učinkovitiji, a na nižim tlakovima je ta razlika vrlo uočljiva. To nam daje uvid u učinkovitost LS sustava i uštede koje se mogu ostvariti primjenom istog.



Slika 17: Graf učinkovitosti sustava

Izvor za slike – skice LS sustava: [9]

Osnovne značajke LS regulacije rada pumpe:

- konstantan protok kroz razvodnik bez obzira na iznos opterećenja izvršnog elementa
- konstantan protok kroz razvodnik bez obzira na promjenu brzine vrtnje pogonskog stroja
- jednostavno rasterećenje pumpe i rad pumpe na niskom tlaku
- manje zagrijavanje ulja, odnosno manji gubici energije u odnosu na standardne sustave.

Nedostaci LS sustava: cijena, složenost sustava, potreba za dobro osposobljenim i uvježbanim osobljem koje može upravljati sustavom i održavati ga.

4. Komponente mjernog sustava

Mjere se pomaci na svakoj od upravljanih osi. Budući da imamo 2 rotacijske i 1 translacijsku os, tome su prilagođeni i mjerni uređaji.

4.1. Rotacijske osi

Za mjerenje kuta zakreta na 1. rotacijskoj osi odabran je rotacioni davač RLS **RM36 VA**, slika 18, mjernog područja 360°.

Za mjerenje kuta zakreta na 2. rotacijskoj osi odabran je rotacioni davač RLS **RM36 VB** mjernog područja 180°, budući da 2. os ima manji radni kut.



Slika 18: Rotacioni davač pozicije

Karakteristike:

- visokobrzinski magnetni rotacioni davač pozicije
- beskontaktna konstrukcija
- radni napon: 24V
- izlazni napon: 0-10 V DC
- maksimalna brzina: 30 000 okr/min

Prilog 9: Rotacioni senzor RM36

4.2. Translacijska os

Za mjerenje položaja translacijske osi odabran je potezni senzor s analognim izlazom Micro-epsilon WPS-2100-MK77-P25, slika 19. Sam senzor montiran je na statični dio ruke, a kraj mjerne žice na vrh dvoradnog teleskopskog cilindra.



Slika 19: Potezni senzor

Karakteristike:

- mjerno područje: 0-2100 mm
- rezolucija: 0,55 mm
- senzorski element: žičani potencijometar
- izlazni napon: 0-10 V DC
- izlazna struja: 4-20 mA

Prilog 10: Senzor linernog pomaka MK77

4.2. Podizni cilindar

Zbog dobivanja što bolje slike o stanju sila u manipulatoru, ispod podiznog cilindra postavljen je tlačno-vlačni senzor aksijalne sile u cilindru. Odabran je prema maksimalnoj sili u cilindru koja iznosi $F_c=16 \text{ kN}$. Iz proizvodnog programa tvrtke HBM odabran je model **1-U9C/20kN**, slika 20, i pripadajuće pojačalo 1-RM4220.



Slika 20: Tlačno – vlačni senzor sile

Karakteristike senzora:

- mjerni princip: tlačno-vlačni senzor sile
- mjerni opseg: 2-20 kN

Prilog 11: Senzor sile U9C

4.3. Mjerenje tlaka u tlačnim vodovima

Tlačnim senzorima Siemens SITRANS P220 (7MF1567), slika 21, tlak se mjeri na A i B priključku hidromotora, kako bi imali podatak o opterećenju hidromotora.



Slika 21: Senzor pritiska u tlačnim vodovima

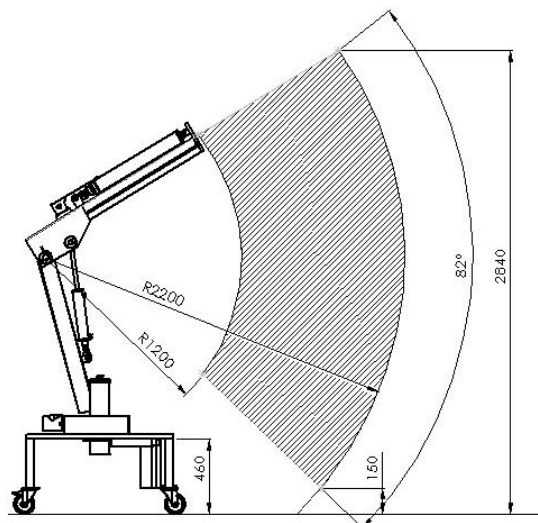
Karakteristike:

- mjerni princip: piezorezistivni mjerač
- mjerenje relativnog tlaka
- mjerno područje: 0-250 bar
- izlazni signal: analogni, napon 0-10 V DC

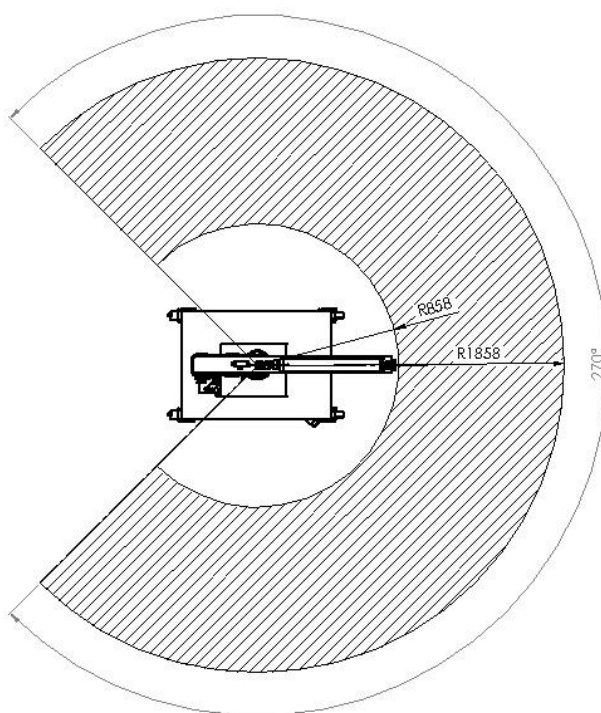
Prilog 12: Senzor tlaka SITRANS P220 (7MF1567)

5. Ostvarene radne karakteristike

Manipulatorom je moguće podići predmet s poda (kada je montirana prihvatnica) i premjestiti ga u neku točku unutar osjenčanog područja prema slikama 22 i 23. To je dio volumena između kugli Ø2400mm i Ø4400 mm te unutar kuta od 270°.



Slika 22: Okomiti pomak ruke manipulatora



Slika 23: Kut zakreta manipulatora

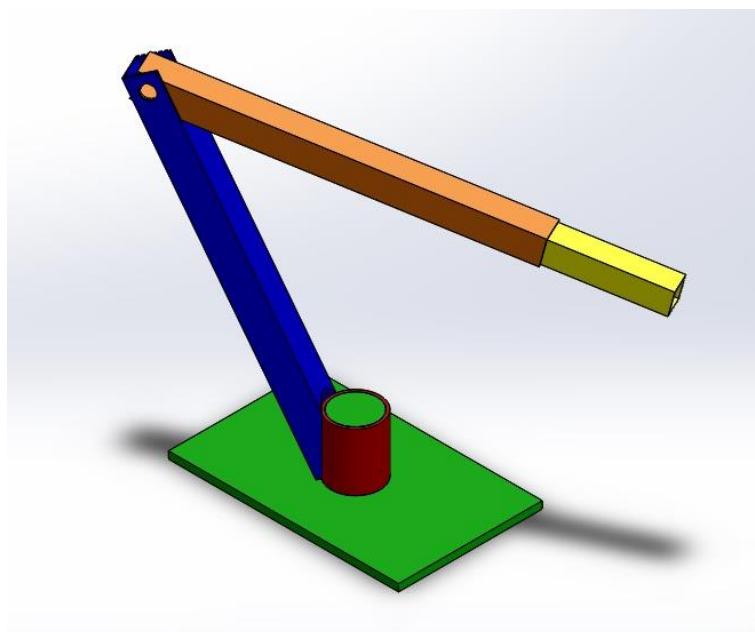
6. Izrada EHROM-a

6.1. Razrada konstrukcije

Ideja izrade manipulatora kao nastavnog pomagala nastala je kroz potrebu za opremanjem laboratorija za automatizaciju u kojem bi studenti mogli vidjeti razne hidraulične elemente i sustave u praktičnoj primjeni.

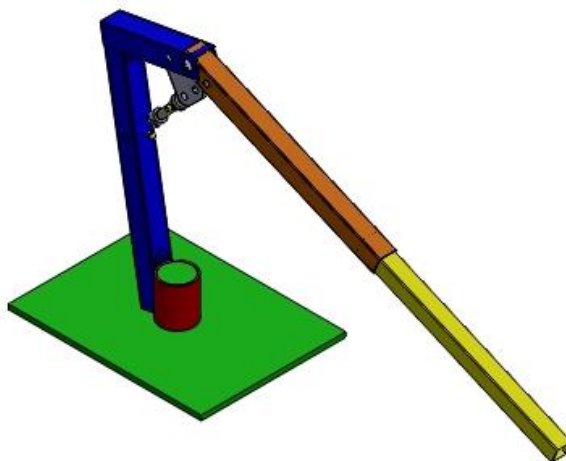
Kroz projekt EHROM nastoji se prikazati upravljanje manipulatorom pomoću hidromotora za realizaciju prve rotacije, dvoradnim hidrauličnim cilindrom za upravljanje druge rotacije i, pomalo nestandardno, dvoradnim teleskopskim cilindrom za realizaciju translacije linearne osi.

Nakon upoznavanja s idejom o konstrukciji, veličini manipulatora, nosivosti i elementima koje bi trebalo ugraditi u manipulator, krenulo se u razradu konstrukcije. Prva skica, slika 24, manipulatora predstavila je samo mogućnosti realizacije zglobova i u većoj mjeri se zadržala do realizacije projekta.



Slika 24: Prva skica manipulatora

Drugačije rješenje izvedbe drugog zgloba razmatrano je u konfiguraciji na slici 25; pokušalo se manjim hodom hidrauličnog cilindra i zglobnim četverokutom postići veći hod teleskopske ruke i sklapanje do osnovne ploče manipulatora.



Slika 25: Skica sa zglobnim četverokutom

6.2. Izrada osnovne ploče

Osnovna ploča je izrezana iz pločevine debljine 20 mm i zatim obrađena u THK na obradnom centru Victor Vcenter-102E, slika 26 i 27. Obrađen je provrt kroz koji prolazi središnja osovinica i površina na koju naliježe aksijalni ležaj i nosači pužnog vijka, slika 28, kako bi se osigurala točnost pozicioniranja osi kola i vijka.



Slika 26: Obradni centar, obrada osnovne ploče



Slika 27: Ploča stegnuta za obradu



Slika 28: Obradena osnovna ploča

6.3. Izrada prijenosa prve osi

Nakon odabira početnog izgleda manipulatora, krenulo se u razradu pogona prve osi koja treba biti pokretana hidromotorom. Zbog velikog broja okretaja hidromotora nije moguće izravno spojiti hidromotor na osovinu.

Moguće izvedbe zupčaničkog prijenosa su bile:

- zupčanički par velikog zupčanika na pokretnom dijelu i malog na osnovnoj ploči pokretanog hidromotorom,
- pužno kolo s vijkom.

Kroz razgovor s kolegama inženjerima i proizvođačem zupčanika odabrano je pužno kolo s vijkom. Predobrada pužnog kola napravljena ju u THK, slika 29, odabran je materijal SL 25 koji je bio dostupan sa skladišta materijala, a opcija je bila bronca (CuSn12).



Slika 29: Predobrađeno pužno kolo

Kolo je izrađeno do kraja i ozubljeno, te uz njega izrađen pužni vijak u riječkom poduzeću JLM Perković, slika 30.

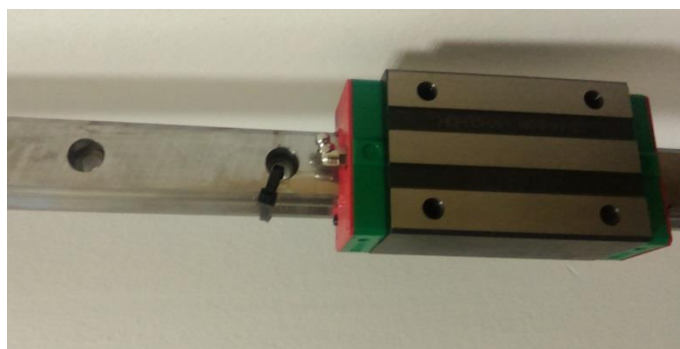


Slika 30: Izrađeno pužno kolo i pužni vijak

6.4. Izrada linearnog zgloba

Početna ideja za izvedbu linearne osi bila je klizanje manje unutrašnje cijevi kroz veću vanjsku kako je prikazano na slici 23. Ta ideja je odbačena zbog moguće pojave značajnog trenja, što bi značilo trzaje u kretanju linearne osi i time nemogućnost kvalitetnog mjerenja i upravljanja tom osi.

Da bi se trenje smanjilo na minimum, odabrano je rješenje koje se koristi na alatnim strojevima kao vodilica za linearne osi. Prema traženoj nosivosti iz kataloga je odabrana vodilica HIWIN HGH 35 HA, slika31.



Slika 31: Linearna vodilica

Vodilica je pravokutnog presjeka pa su kao logično rješenje za lagano postavljanje odabrani standardni UNP-profil. Veći nepokretni profil odabran je tako da u njega stane statični dio vodilice, a manji pokretni dio tako da ulazi u veći profil, slika 32.



Slika 32: Sklop profila i linearne vodilice

Površina na koju se postavlja klizna vodilica planski je glodana kako bi se osigurala ravnost površine za montažu, slika 33.



Slika 33: Obrada površine za montažu linearne vodilice

Nepokretni dio linearnog zgloba učvršćen je na bočne ploče koje sa stupom čine drugi rotacijski zglob, slika 34.



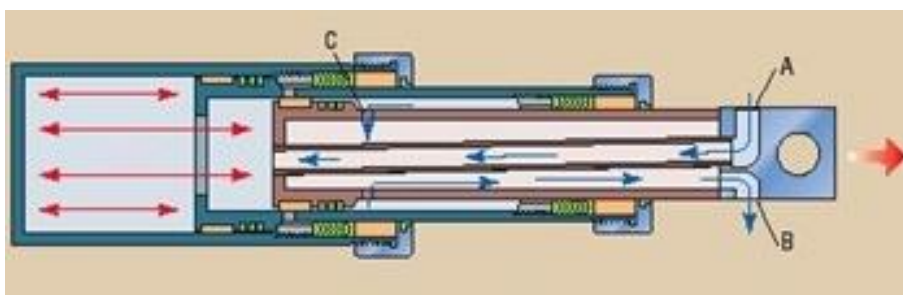
Slika 34: Sklop većeg profila i bočnih ploča

6.5. Izrada teleskopskog dvoradnog cilindra

Izrada ovakvog cilindra iziskivala je malo istraživanja oko mogućih izvedbi i veličina segmenata cilindra, budući da nije u standardnom proizvodnom programu THK. Najviše je pomoglo iskustvo u popravljajući sličnih cilindara, gdje je sakupljeno znanje o načinu rada i konstrukciji dvoradnog teleskopskog cilindra. Princip rada prikazan je na slici 35 i opisan u

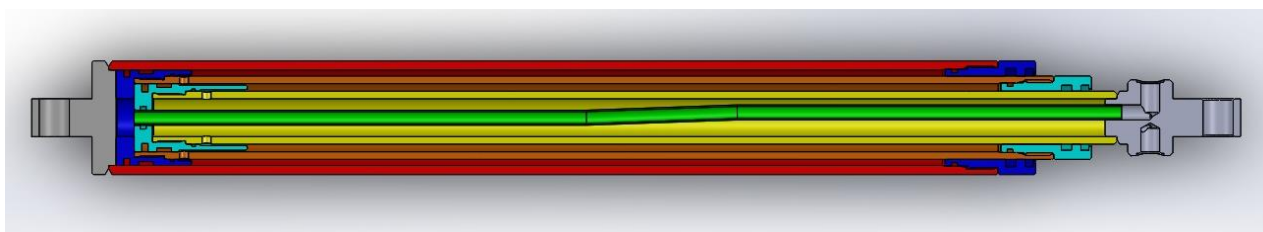
prilogu 13: Parker princip rada.

Posebnost ove izvedbe je smještaj priključaka A i B, koji se nalaze na ušici manje klipnjače, kako bi bilo moguće dvoradno djelovanje cilindra bez povlačenja gibljivih cijevi do druge strane cilindra. Prilikom izvlačenja cilindra, kao što je prikazano na slici, ulje prolazi kroz priključak A i spojnu cijev te puni donju stranu većeg i manjeg klipa. Istodobno kroz spojni kanal C ulje iz srednje komore izlazi u unutrašnji prostor manje cijevi i kroz priključak B se vraća prema razvodnom ventilu.



Slika 35: Princip rada dvoradnog teleskopskog cilindra

Dimenzioniran je prema dostupnom materijalu na skladištu THK i minimalnoj veličini unutrašnje cijevi cilindra (Ø35), slika 36.



Slika 36: Presjek dvoradnog teleskopskog cilindra

U trenutku izrade cilindra na tržištu nije bila dostupna manja tvrdokromirana cijev pa je izrađena iz honovane cijevi $\varnothing 25\text{H8}/\varnothing 35$, brušena na brusilici za vanjsko brušenje između šiljaka, slika 37, zatim je vanjska površina tvrdokromirana slojem kroma $25\text{ }\mu\text{m}$, završno brušena na toleranciju $\varnothing 35\text{f7}$ te polirana.



Slika 37: Vanjsko brušenje manje cijevi cilindra

Cilindar u dijelovima prije montaže izgleda kao na slici 38.



Slika 38: Dijelovi dvoradnog teleskopskog cilindra

Nakon zavarivanja i montaže sklop dvoradnog teleskopskog hidrauličnog cilindra izgleda kao na slici 39.



Slika 39: Sklop dvoradnog teleskopskog cilindra

6.6. Manipulacija i niveliranje

Manipulator je postavljen na četiri noge izrađene od kvadratne cijevi 50x50. Kako bi manipulator bilo moguće jednostavno i lako premještati ispod nogu postavljeni su kotači, dva fiksna i dva rotirajuća s kočnicom, slika 40.



Slika 40. Kotač za manipulaciju

Prilog 14: Kotači

Za nivelaciju manipulatora nakon izvlačenja podesivih konzolnih stabilizatora služe četiri podesiva vijka s podlogom, slika 41.



Slika 41. Vijak za nivelaciju

Prilog 15: Vijak za nivelaciju

7. Troškovnik izrade

Na početku projekta bilo je teško procijeniti iznos koji će biti potreban za realizaciju. S entuzijazmom se krenulo u istraživanje mogućih konfiguracija. Odabirom pojedinih rješenja za konstrukciju ili hidraulične komponente bilo je moguće utvrditi pravu cijenu koštanja.

Mehanička konstrukcija izrađena je u THK, pužni prijenos u JLM Perkoviću, hidroagregat u RASCO-u, a većina hidrauličnih komponenti je kupljena. Posebna zahvala ide tvrtki Parker koja je donirala LS klipnu pumpu u znanstvene svrhe te njihovom zastupniku u Hrvatskoj, tvrtki Sormiko.

U tablici 1 dan je približan pregled troškova po komponentama.

Tablica 1: Troškovnik

R.br	Naziv	Cijena (kn)	napomena	dobavljač
1.	Izrada konstrukcije	~ 20.000,00	Procjena	THK, Kutina
2.	Dvoradni hidraulični cilindar	950,00		THK, Kutina
3.	Teleskopski hidr. cilindar	2.100,00		THK, Kutina
4.	Hidromotor EPM 50	650,00		M+S Hidraulic
5.	Pužni par	~ 2.300,00	donacija	JLM Perković, Rijeka
6.	Teleskopska vodilica	1.944,84		INDOP, Sisak
7.	Kotači, stabilizatori	1.113,85		INDOP, Sisak
8.	LS klipna pumpa PV 23	~ 14.000,00	donacija	Sormiko / Parker
9.	Hidroagregat	~ 15.000,00	procjena	Rasco, Kalinovac
10.	Spojni elementi	~ 800,00		
11.	Proporcionalni ventilski blok PVG 32	21.044,28		Bibus / Danfoss
12.	Joystick Prof 1 + kabel	5.489,11		Bibus
13.	Senzori			
	Potezni potencijometar MK 77	2.425,05		Tipteh, Zagreb
	Senzor tlaka Sitrans P220, 4 kom.	3.635,76		Siemens, Zagreb
	Senzor sile U9C + pojačalo	7.860,88		TRCpro Kranj / HBM
	Rotacioni enkoder RM 36, 2 kom.	2.252,24		RLS Merilna tehnika
14.	Elektroormar	~ 1.200,00	procjena	
15.	Završna površinska zaštita	~ 500,00	procjena	POD Dežanovac

8. Zaključak

U radu je obrađena konstrukcija elektrohidrauličnog manipulatora, odabir električnih i hidrauličnih komponenti te mjernih senzora. Obuhvaćen je presjek znanja iz različitih područja strojarstva (mehaničke konstrukcije, konstrukcije zupčanika i hidrauličnih cilindara, hidraulike, strojarskog dizajna). Istovremeno je posebna pažnja posvećena otvorenosti i modularnosti sustava. Izradom dijelova i montažom došlo se do jedne od mogućih izvedbi manipulatora koja će poslužiti studentima za izradu radova iz područja automatizacije.

Ispitivanjem u realnom okruženju bit će moguće ocijeniti koncepciju i izvedbu te dati smjernice za moguće optimizacije.

9. Literatura

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- [8] Tolj, I., LS regulacija rada crpke - diplomski rad, Sveučilište u Splitu, Fakultet elektrotehnike, strojarstva i brodogradnje, 2005.
- [9] Load Sense Controls - Hydraulic Guide, <http://www.hydraulicguide.com/load-sense-controls/>, 24.01.2015.
- [10] Efficient Mobile Hydraulic Systems - Mobile Hydraulic Tips, <http://www.mobilehydraulictips.com/efficient-mobile-hydraulic-systems/>, 24.01.2015.

Prilog 1: Linearna vodilica HGH35 HA

SEARCH

CZ EN SK RU BG

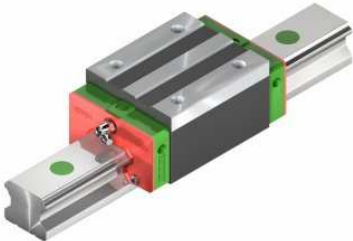
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Home > Products > Linear Guideways > Ball Guideway > Series HG > HGH

HGH

poptávka

- LINEAR GUIDEWAYS
- BALL SCREWS
- BALL BUSHINGS
- POSITIONING SYSTEMS
- LINEAR ACTUATORS



Square linear guide block

Applications:

- Machining centers
- Machine tools
- Heavy cutting machines
- Grinding machines
- Injection molding machine
- Automatic equipment
- High speed transfer device

Download

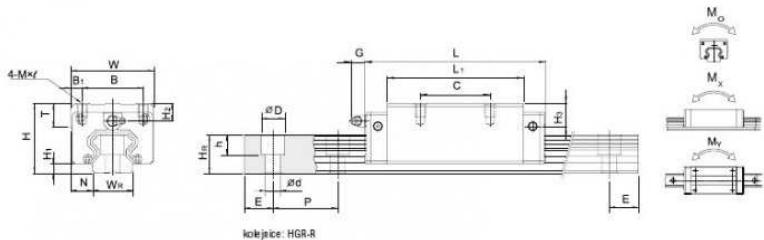
- Katalogový list - HGH (pdf, 125.19kB)
- Katalog - lineární vedení (pdf, 5144.38kB)
- Lubrication instruction for linear guideways (pdf, 1892.69kB)
- Lubrication grease HIWIN PLO-05 (pdf, 303.19kB)

More informations

- Objednací kód - Typ HG, EG (png, 49.53kB)
- Objednací kód - Typ HG, EG (png, 59.2kB)

Related links

- Mazání



Part number	H	W	B	C	L	MxL	C _{dyn} [N]	C _{stat} [N]	M ₀ [Nm]	M _x [Nm]	M _y [Nm]	3D (STP)
HGH15CA	28	34	26	26	61,4	M4x5	11380	25310	170	150	150	
HGH20CA	30	44	32	36	77,5	M5x6	17750	37840	380	270	270	
HGH20HA	30	44	32	50	90,3	M5x6	21180	48840	480	470	470	
HGH25CA	40	48	35	35	83	M6x8	26480	56190	640	510	510	
HGH25HA	40	48	35	50	103,6	M6x8	32750	76000	870	880	880	
HGH30CA	45	60	40	40	97,4	M8x10	38740	83060	1060	850	850	
HGH30HA	45	60	40	60	120,4	M8x10	47270	110130	1400	1470	1470	
HGH35CA	55	70	50	50	112,4	M8x12	49520	102870	1730	1200	1200	
HGH35HA	55	70	50	72	138,2	M8x12	60210	136310	2290	2080	2080	
HGH45CA	70	86	60	60	138	M10x17	77570	155930	3010	2350	2350	
HGH45HA	70	86	60	80	169,8	M10x17	94540	207120	4000	4070	4070	
HGH55CA	80	100	75	75	165,7	M12x18	114440	227810	5660	4060	4060	
HGH55HA	80	100	75	95	203,8	M12x18	139350	301260	7490	7010	7010	
HGH65CA	90	126	76	70	198,2	M16x20	163630	324710	10020	6440	6440	
HGH65HA	90	126	76	120	257,6	M16x20	208360	457150	14150	11120	11120	

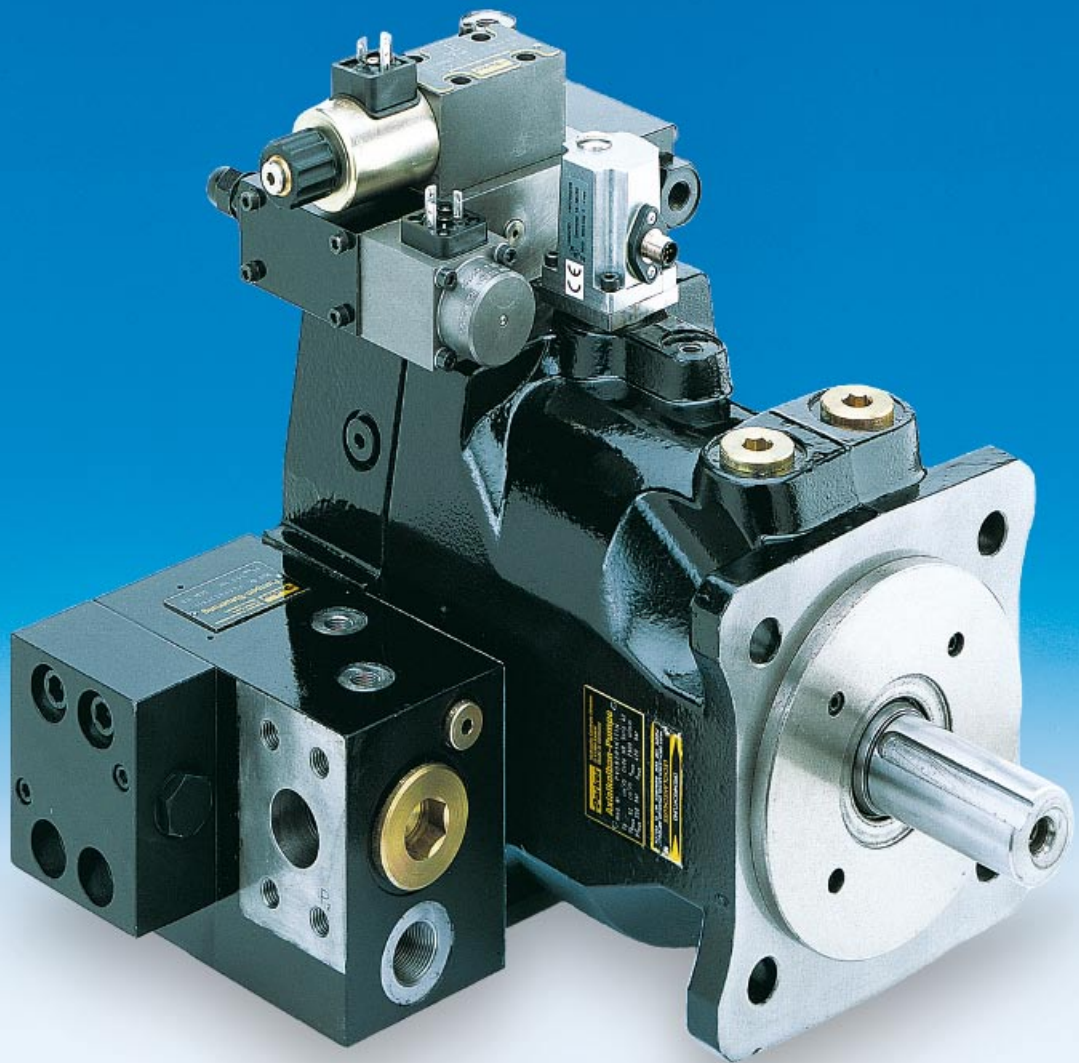
Prilog 2: Pumpa PV 32

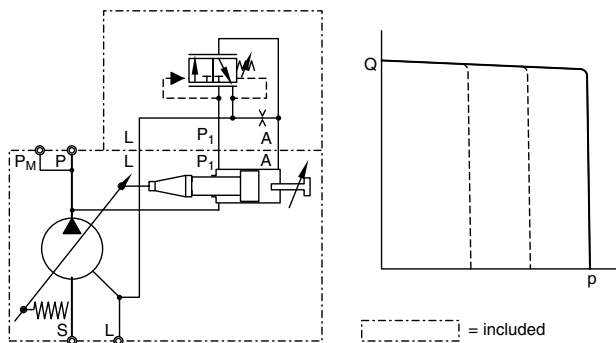
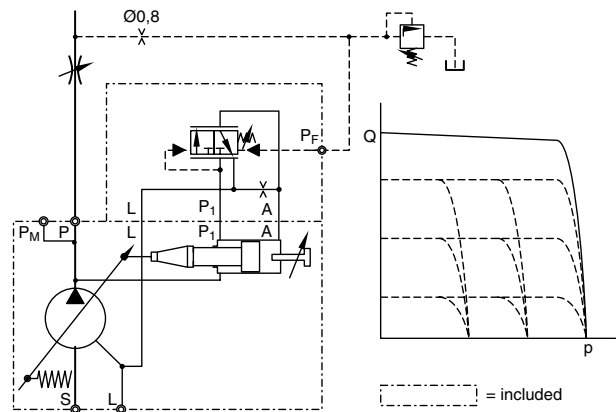


Axial Piston Pump Series PV

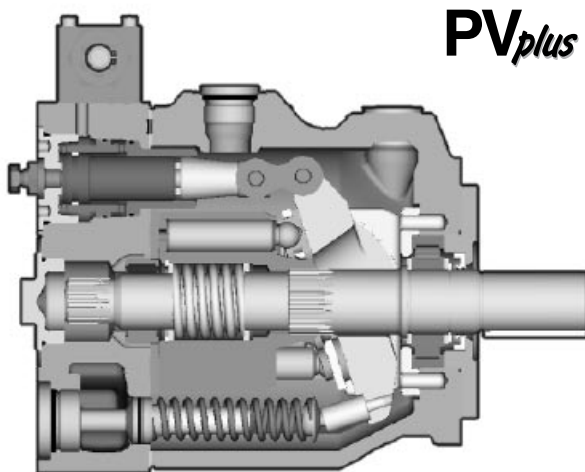
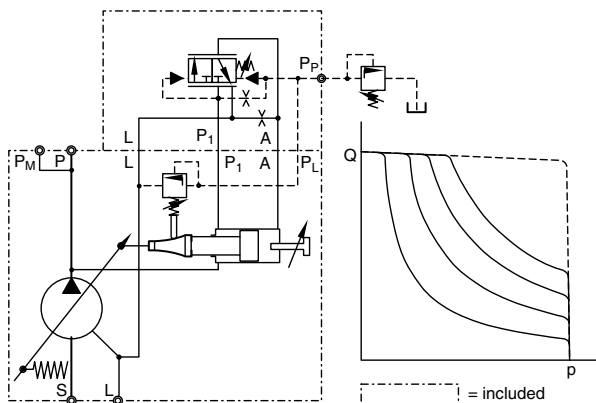
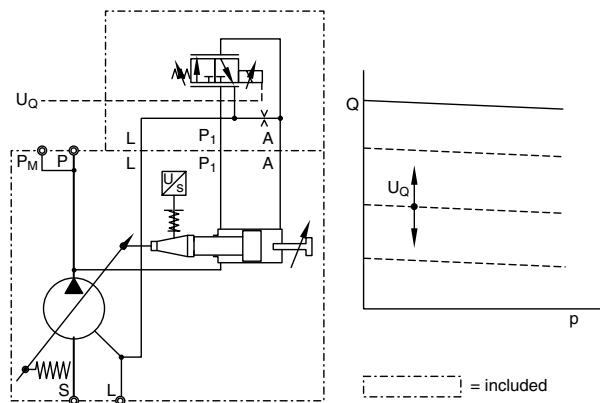
Variable Displacement

*Catalogue HY30-3243/UK
April 2006*



Pump with Standard Pressure Compensator, code F*S**Pump with Load-Sensing Compensator, code FFC****Technical Features**

- Mounting interface according to VDMA-standards sheet 24560 part 1
- Standard: 4-hole flange ISO 3019/2 (metric)
- Large servo piston with strong bias spring achieves fast response; e.g. for PV042
upstroke < 75 ms
downstroke < 45 ms
Note: Follow installation instructions.
- Reduced pressure peaks due to active decompression of system at downstroke
- Also at low system pressure reliable compensator operation. Lowest compensating pressure 12-15 bar
- 9 piston and precompression technology (precompression volume) result in unbeaten low outlet flow pulsation.
- Rigid and FEM-optimized body design for lowest noise level
- Complete compensator program
- Thru drive for 100% nominal torque

**Pump with Power Compensator, code *LB****Pump with Electrohydr. Displacement Control, code FPV**

Technical data

Displacement	[cm ³ /rev]	from 16 to 270
Operating pressures		
Outlet	[bar]	nominal pressure p _N 350
	[bar]	max. pressure p _{max.} 420 ¹⁾
	[bar]	drain port 2 ²⁾
Inlet min.	[bar]	0.8 (absolute)
max.	[bar]	16
Minimum speed	[min ⁻¹]	300 min ⁻¹
Mounting interface		4-hole flange ISO 3019/2
Installation		drain port as high as possible

¹⁾ max. 20% of working cycle

²⁾ peak pressure only



Pump with Standard Pressure Comp.



Pump with Power Comp.



Combination PV/PV



Combination PV/PGP

Selection table

Model	Max. displacement [cm ³ /rev]	Output flow at 1500 min ⁻¹ [l/min]	Input power at 1500 min ⁻¹ and 350 bar [kW]	Max speed * [min ⁻¹]	Moment of inertia [kgm ²]	Weight [kg]
PV016	16	24	15.5			
PV020	20	30	19.5	3000	0.0017	19
PV023	23	34.5	22.5			
PV063	63	94.5	61.5	2800		
PV080	80	120	78	2500	0.018	60
PV092	92	138	89.5	2300		
PV140	140	210	136	2400	0.030	90
PV180	180	270	175	2200		
PV270	270	405	263	1800	0.098	172

* The maximum speed ratings are shown for an inlet pressure of 1 bar (absolute) and for a fluid viscosity of $\nu = 30 \text{ mm}^2/\text{s}$.

Ordering Code

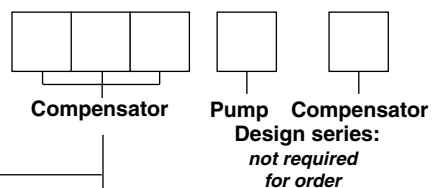
PV											
Axial piston pump variable displacement high pressure version	Size and displacement	Rotation	Variation	Mounting code	Threads	Thru drive	2nd pump	Seals	Compensator	Pump Design series: (not required for order)	Compensator Design series: (not required for order)
Code	Displacement	Code	Rotation ¹⁾	Code	Variation	Code	Thru drive option no adaptor for 2nd pump	Code	Seals	Code	2nd pump option ⁷⁾
016	16 cm ³ /rev	R	Clockwise	1	Standard	T	Single pump prepared for thru drive	N	NBR	1	Single pump, no 2nd pump and coupling
020	20 cm ³ /rev	L	Counter clockwise	9	Reduced displacement adjusted ²⁾		With adaptor for 2nd pump	V	FPM	2	PV140 or PV180 mounted
023	23 cm ³ /rev					Y ⁸⁾	SAE AA, Ø 50.8mm	E	EPDM	3	PV or PVM pump mounted
063	63 cm ³ /rev					A	SAE A, Ø 82.55mm	W	NBR with PTFE shaft seal	4	Gear pump series PGP mounted
080	80 cm ³ /rev					B	SAE B, Ø 101.6mm	P	FPM with PTFE shaft seal		
092	92 cm ³ /rev					C ⁹⁾	SAE C, Ø 127mm	S	EPDM with PTFE shaft seal		
140	140 cm ³ /rev					D ¹⁰⁾	SAE D, Ø 152.4mm				
180	180 cm ³ /rev					E ¹¹⁾	SAE E, Ø 165.1mm				
270	270 cm ³ /rev					G ¹²⁾	Metric, Ø 63mm				
						H	Metric, Ø 80mm				
						J	Metric, Ø 100mm				
						K ⁹⁾	Metric, Ø 125mm				
						L ¹⁰⁾	Metric, Ø 160mm				
						M ¹¹⁾	Metric, Ø 200mm				

Code	Port ⁴⁾	Threads ⁵⁾
1	BSPP	Metric
3	UNF	UNC
4 ⁶⁾	BSPP	Metr. M14
7	ISO 6149	UNC
8	ISO 6149	Metric ¹⁾

¹⁾ When looked on shaft²⁾ For order specify displacement.³⁾ Codes F and G only for PV140/180, see dimension sheet⁴⁾ Drain, gauge and flushing ports⁵⁾ All mounting and connecting threads⁶⁾ For PV063-PV180 only: pressure port 1 1/4" with 4 x M14 instead of 4 x M12⁷⁾ Specify 2nd pump with full model code⁸⁾ Only for PV016 - PV023⁹⁾ Only for PV032 and larger¹⁰⁾ Only for PV063 and larger¹¹⁾ Only for PV270¹²⁾ Only for PV016 - PV092

Bold letters =
Short-term availability

PV



Standard Pressure Compensator			
Code_		Compensator options	
0	0	1	No compensator
1	0	0	With coverplate, no control function
F	D	S	10 - 140 bar, spindle + lock nut
F	H	S	40 - 210 bar, spindle + lock nut
F	W	S	70 - 350 bar, spindle + lock nut
			Remote Compensator options
F	R		Remote pressure compensator
F	S		Variation R, for quick unload valve
F	F		Load-Sensing compensator
F	T		Two valve load-sensing compensator
			Variations for Remote Compensator
		C	External pressure pilot ¹³⁾
		1	NG6/D03 interface top side
		2	Like 1 but with ext. pilot port ¹⁵⁾
		P	Pilot valve PVAC1P* mounted
		D	Proportional pilot valve type PVACPP* mounted
		L	Pilot valve with DIN lock mounted
		Z	Accessory mounted ¹⁴⁾

Power compensator									
Code			Displacement				Compensator option		
			016 023	063 092	140	180	270	Nom. power [kW] at 1500 min ⁻¹	Nom. torque [Nm]
B			x					3	19.5
C			x					4	26
D			x					5.5	36
E			x					7.5	49
G			x	x				11	71
H			x	x				15	97
K			x	x	x			18.5	120
M				x	x	x		22	142
S				x	x	x		30	195
T				x	x	x	x	37	240
U				x	x	x	x	45	290
W				x	x	x	x	55	355
Y					x	x	x	75	485
Z					x	x	x	90	585
2						x	x	110	715
3							x	132	850
Function									
	L		x	x	x	x	x	Power compensator	
	C		x	x	x	x	x	Power compensator and load-sensing	
Variation									
		A	x	x	x	x	x	NG6 interface top side	
		B	x	x	x	x	x	No pressure compensation	
		C	x	x	x	x	x	Adjustable pressure compensation	
		D	x	x	x	x	x	Proportional pilot valve PVACPP* mounted	
		Z	x	x	x	x	x	Accessories mounted ¹⁴⁾	

Electrohydraulic compensator		
Code		Compensator option
Pilot pressure supply		
F		Standard (internal), no shuttle valve
U		Elbow manifold, compensator horizontal ¹⁶⁾
Function		
P		Proportional displacement control
Variation		
	V	Standard, no pressure compensation
	R	Remote pressure comp. NG6 interface
	G	Variation R, Pressure sensor and proportional pilot valve mounted for pressure resp. power control
	D	Variation R, Proportional pilot valve PVACPP* mounted
	Z	Variation R, accessories mounted ¹⁴⁾
	S	Remote pressure comp., NG6 interface top side, for quick unload valve
	T	Variation S, pressure sensor and proportional pilot valve mounted for pressure resp. power control
	P	Remote pressure comp., NG6 interface top side, for preload and quick unload manifold
	E	Variation P, pressure sensor and proportional pilot valve mounted for pressure resp. power control

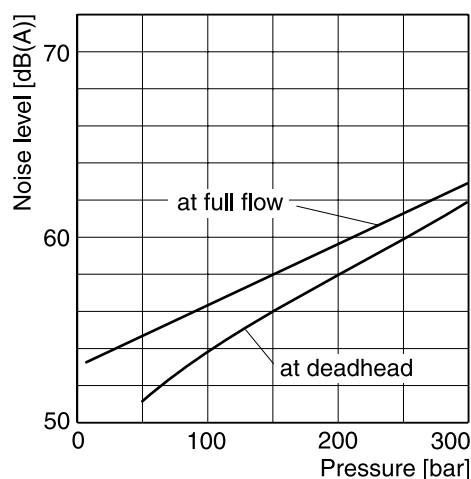
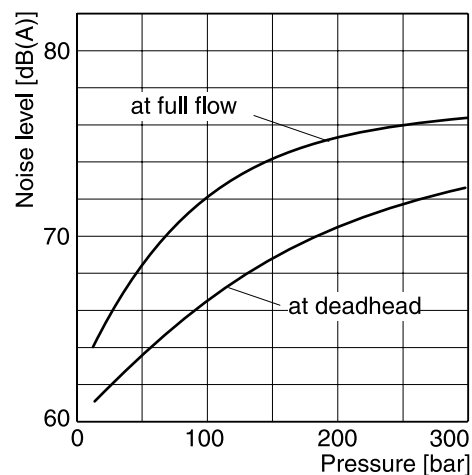
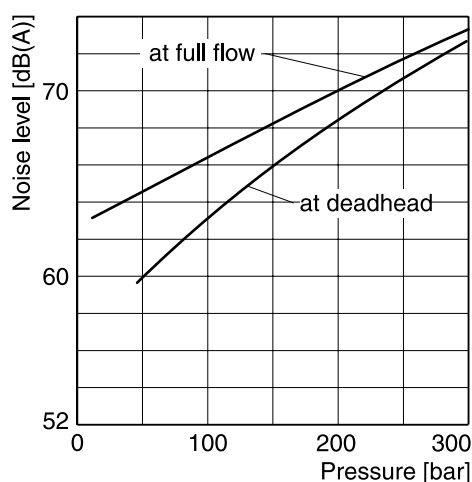
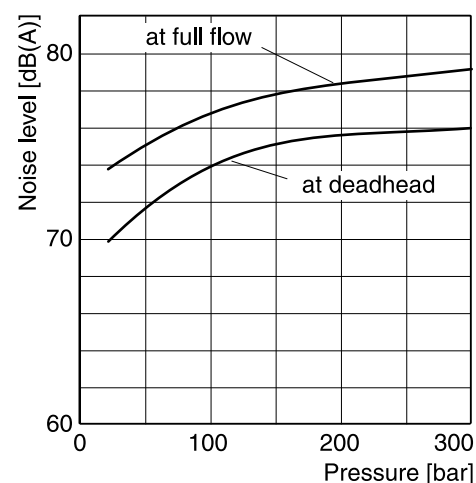
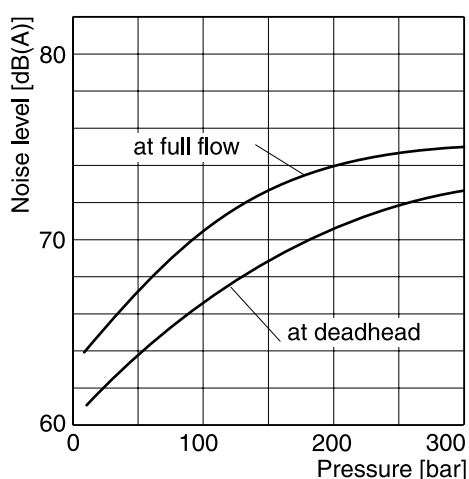
¹⁶⁾ not for *UPV**Note**Compensator differential Δp is to be adjusted:Remote pressure comp., power comp. 15 ± 1 bar
(Codes FR*, FT*, *L*, *C*, FPR, FPD, FPZ, FPG)With quick unload manifold 12 ± 1 bar

(Codes FS*, FPS, FPT, FPP, FPE)

Load-Sensing comp. (not power comp.) 10 ± 1 bar
(Codes FF*)

The ordering code PVACPP* correspond to the DSAE1007P07*

¹³⁾ Not for two-valve-compensator¹⁴⁾ Accessories not included, please specify on order with full model code.¹⁵⁾ Only for Codes *FR* and *FT*
Bold letters =
Short-term availability

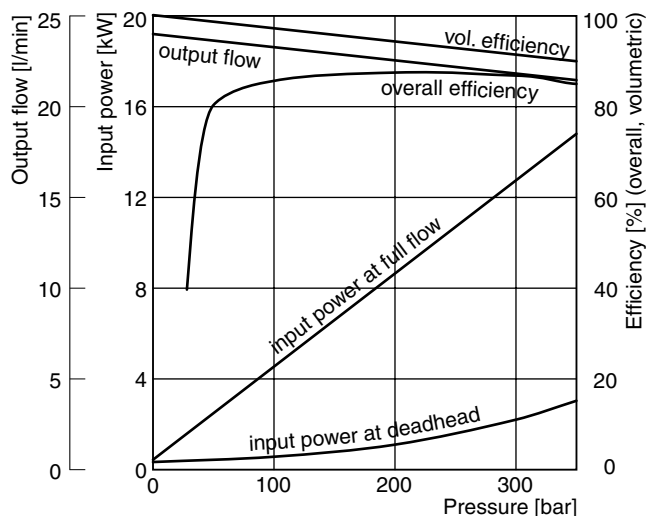
PV016 - PV023**PV180****PV063 - PV092****PV270****PV140**

Typical sound level for single pumps, measured in anechoic chamber according to DIN 45 635, part 1 and 26. Microphone distance 1m; speed: $n = 1500 \text{ min}^{-1}$.

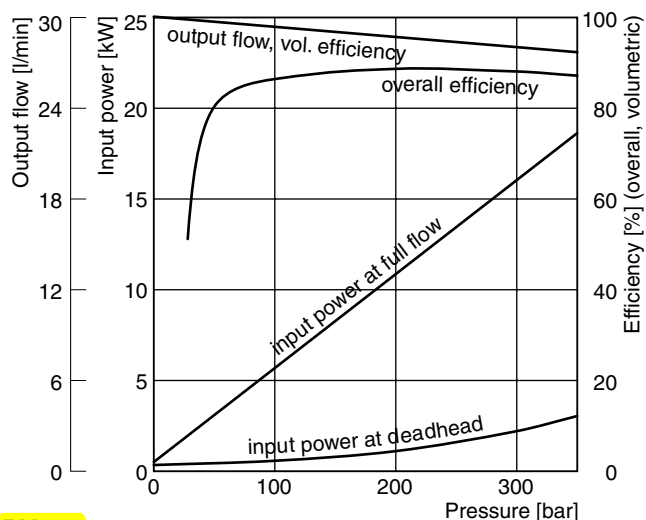
All data measured with mineral oil viscosity $30 \text{ mm}^2/\text{s}$ (cSt) at 50°C .

Efficiency, power consumption

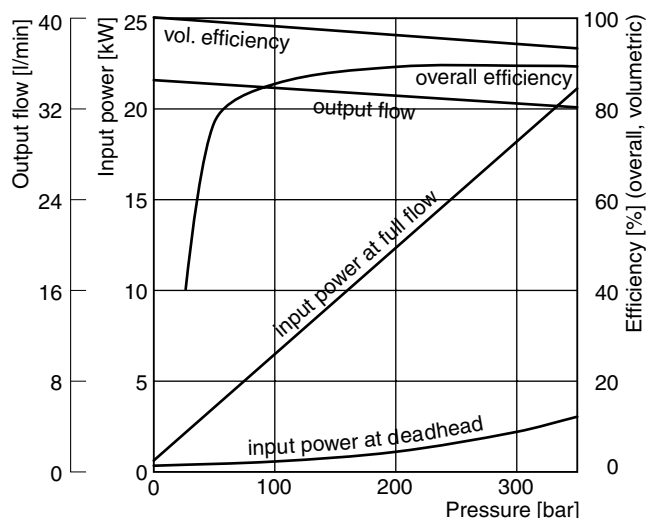
PV016



PV020



PV023



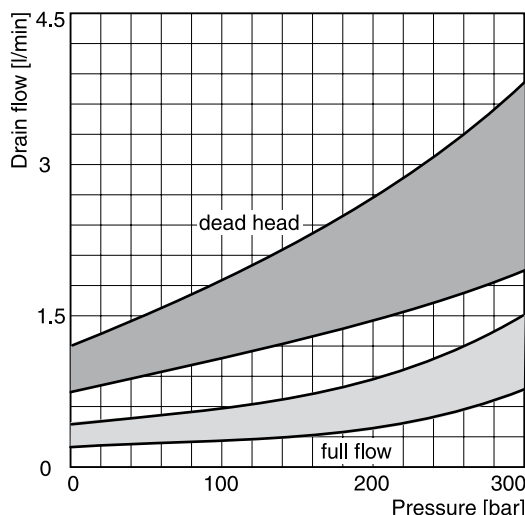
Efficiency and case drain flows PV016, PV020, PV023

The efficiency and power graphs are measured at an input speed of $n = 1500 \text{ min}^{-1}$, a temperature of 50°C and a fluid viscosity of $30 \text{ mm}^2/\text{s}$.

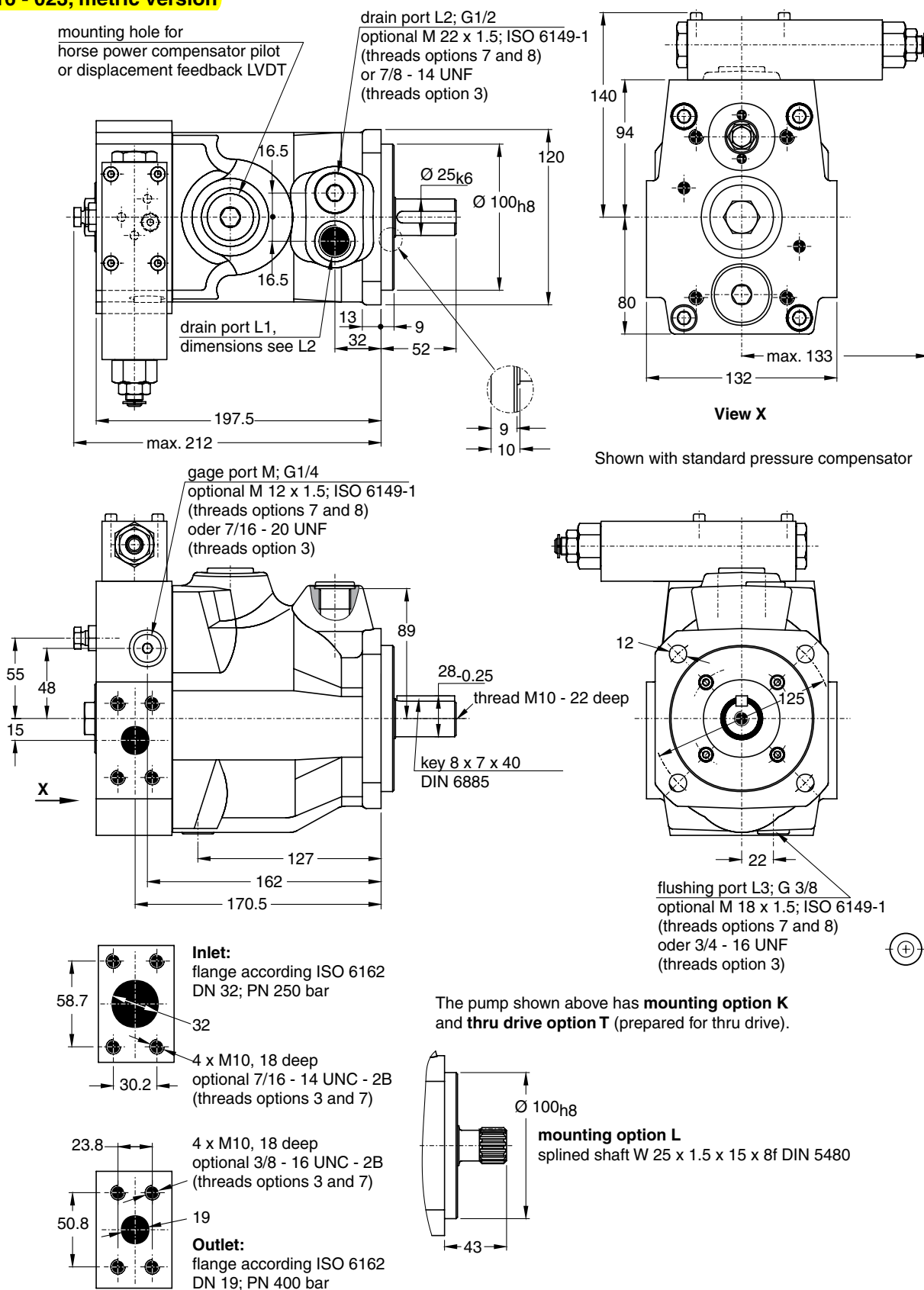
Case drain flow and compensator control flow leave via the drain port of the pump. To the values shown are to be added 1 to 1.2 l/min, if at pilot operated compensators (codes FR*, FF*, FT*, power compensator and p/Q-control) the control flow of the pressure pilot valve also goes through the pump.

Please note: The values shown below are only valid for static operation. Under dynamic conditions and at rapid compensation of the pump the volume displaced by the servo piston also leaves the case drain port. This dynamic control flow can reach up to 40 l/min! Therefore the case drain line is to lead to the reservoir at full size and without restrictions as short and direct as possible.

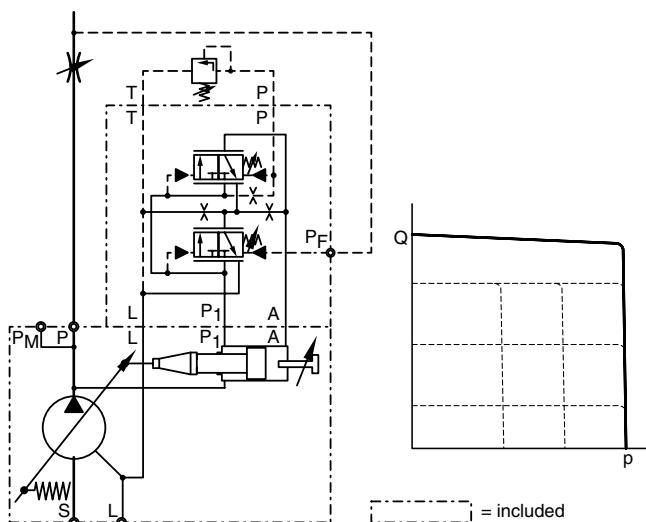
Case drain flows PV016-023



PV016 - 023, metric version



For further information about flanges see catalogue No. 4039/UK „Pressure Hydraulic Flanges“ (on request).
Shown is a clockwise rotating pump. Counter clockwise rotating pumps have inlet, outlet and gauge ports reversed.



Prilog 3: Pužni vijak i kolo

Schneckenradsätze

Worm gear units

DIN 3975/ 3976

Gearing right hand

Worm

171 - - - - -
hardened/ ground

172 - - - - -
not hardened
not ground

Steel: 1.7131
(16 MnCr 5)

DIN 3975/ 3976

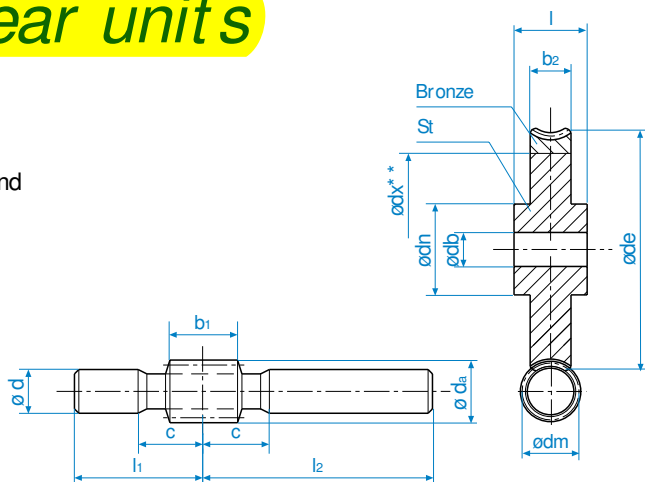
Verzahnung rechtssteigend

Schneckenwelle

171 - - - - -
gehärtet/ geschliffen

172 - - - - -
nicht gehärtet
nicht geschliffen

Stahl: 1.7131
(16 MnCr 5)



Achsabstand

125 mm

Centre distance

i	Modul Module	z_1^*	d_m	d_a	d	c	l_1	l_2	b_1	[kg]	Bestell Nr. Part No.	Bestell Nr. Part No.
7,25:1	6,3	4	63	75,6	47,5	50	150	250	86	6,52	171-763-463	172-763-463
10,00:1	5	4	50	60	50	68	150	250	69	5,89	171-750-450	172-750-450
12,50:1	4	4	50	58	50	56	150	250	60	6,02	171-740-450	172-740-450
14,50:1	6,3	2	63	75,6	50	68	150	250	86	6,91	171-763-263	172-763-263
20,00:1	5	2	50	60	50	56	150	250	69	5,99	171-750-250	172-750-250
25,00:1	4	2	50	58	50	56	150	250	60	6,02	171-740-250	172-740-250
29,00:1	6,3	1	63	75,6	50	62	150	250	86	6,89	171-763-163	172-763-163
40,00:1	5	1	50	60	50	56	150	250	69	5,99	171-750-150	172-750-150
50,00:1	4	1	50	58	50	56	150	250	60	6,02	171-740-150	172-740-150
62,00:1	3,15	1	53	59,3	50	50	150	250	60	6,19	171-731-153	172-731-153
83,00:1	2,5	1	42,5	47,5	47	50	150	250	50	5,18	171-725-142	172-725-142

Worm wheel

176 - - - - -

Specialbronze **

Hub: Steel

175 - - - - -

Cast iron

Schneckenrad

176 - - - - -

Spezialbronze **

Nabe: Stahl

175 - - - - -

Grauguß

i	Modul Module	z_1^*	z^*	d_e	d_n	d_b	$d_{x^{**}}$	b_2	l	[kg]	Bestell Nr. Part No.	[kg]	Bestell Nr. Part No.
7,25:1	6,3	4	29	206	100	50	148	50	60	11,33	176-763-429	9,87	175-763-429
10,00:1	5	4	40	215	100	50	170	40	60	11,05	176-750-440	9,61	175-750-440
12,50:1	4	4	50	212	100	50	174	34	60	10,25	176-740-450	8,93	175-740-450
14,50:1	6,3	2	29	206	100	50	148	50	60	11,33	176-763-229	9,87	175-763-229
20,00:1	5	2	40	215	100	50	170	40	60	11,05	176-750-240	9,61	175-750-240
25,00:1	4	2	50	212	100	50	174	34	60	10,25	176-740-250	8,93	175-740-250
29,00:1	6,3	1	29	206	100	50	148	50	60	11,33	176-763-129	9,87	175-763-129
40,00:1	5	1	40	215	100	50	170	40	60	11,05	176-750-140	9,61	175-750-140
50,00:1	4	1	50	212	100	50	174	34	60	10,25	176-740-150	8,93	175-740-150
62,00:1	3,15	1	62	206,5	100	50	174	34	60	9,55	176-731-162	8,32	175-731-162
83,00:1	2,5	1	83	215	100	50	186	28	60	9,19	176-725-183	7,95	175-725-183

* z_1 : Zähne - Gangzahl/ Number of teeth - threads; $d_{x^{**}}$ ca. ϕ St/ Bronze; i = Übersetzungsverh/ ratio

Prilog 4: Fag X-life

FAG



Single row FAG X-life angular contact ball bearings

A Member of the
Schaeffler Group

Single row FAG angular contact ball bearings

Cages

Cages

Angular contact ball bearings up to 130 mm bore diameter have as standard a solid window cage made from glass fibre-reinforced polyamide 66 (suffix TVP). This economical cage is also used for sealed angular contact ball bearings.

As standard, bearings with a bore code of 24 or higher have a high-quality solid window cage made from brass (suffix MP).

The range is supplemented by a universally applicable window cage made from sheet steel (JP).

Advantages of the sheet steel cage:

- Insensitive to synthetic lubricant
- Continuous temperature up to 200 °C (for $D \leq 240$ mm, in conjunction with heat treatment to S1)
- Longer grease operating life

Features and availability of cages for single row FAG angular contact ball bearings

Designation	Design	Suffix	Speed parameter	Features	Availability		
			Open bearing, oil lubrication $n \times d_m [\text{min}^{-1} \times \text{mm}]$		70B	72B	73B
					Bore code		
Polyamide cage	Solid window cage, rolling element guided	TVP	< 550 000	Low mass, more favourable price, low noise	04 to 08	00 to 20, 22 to 26	01 to 20, 22 to 26
							
Sheet steel cage	Window cage, JP rolling element guided	JP	< 550 000	Insensitive to synthetic oils, large space for lubricant, low mass, universal cage		00 to 20, 22	01 to 20, 22
							
Brass cage	Solid window cage, rolling element guided	MP	< 900 000	Good speed suitability, high strength		00 to 30	01 to 26
							

Single row FAG angular contact ball bearings

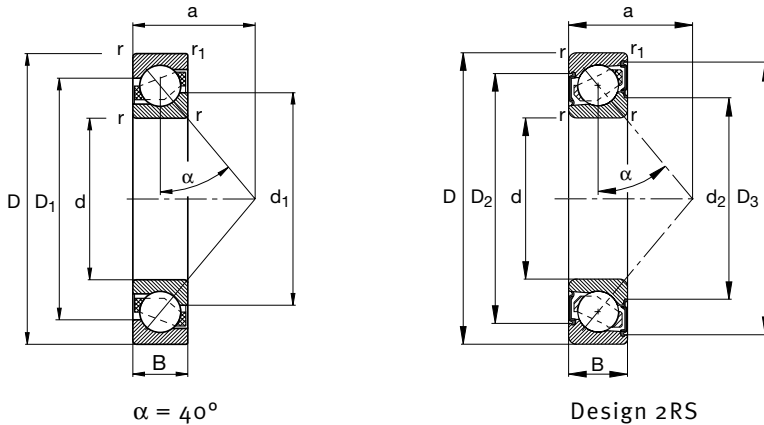
Axial internal clearance and preloading of bearing pairs

Axial internal clearance and preload for angular contact ball bearings of universal design fitted in X and O arrangements								
Bore code	Axial internal clearance or preload of bearing pair					Preload force (UL)		
	Nominal dimension [μm]					F _v [N] max.		
	UA	UO	UL			UL		
	70B, 72B, 73B	70B, 72B, 73B	70B	72B	73B	70B	72B	73B
	Tolerance classes					Tolerance class		
	PN, P6, P5		P5	P5	P5	P5	P5	P5
00	22	0		-3			38	
01	24	0		-4	-5		53	82
02	24	0		-4	-5		62	99
03	24	0		-4	-6		77	123
04	28	0	-4	-5	-6	103	103	146
05	34	0	-4	-4	-6	115	112	200
06	34	0	-5	-5	-7	141	157	250
07	40	0	-5	-6	-7	172	208	300
08	40	0	-5	-6	-8	200	246	385
09	44	0		-6	-9		277	462
10	44	0		-6	-10		288	535
11	46	0		-7	-10		358	600
12	46	0		-7	-10		431	692
13	46	0		-8	-11		492	785
14	50	0		-8	-11		535	877
15	50	0		-8	-12		523	977
16	50	0		-8	-12		615	1077
17	54	0		-8	-13		692	1154
18	54	0		-9	-13		815	1231
19	54	0		-10	-14		892	1331
20	54	0		-11	-14		992	1485
21	58	0		-11	-14		1100	1538
22	58	0		-12	-15		1177	1723
24	58	0		-12	-16		1277	1923
26	60	0		-12	-17		1431	2115
28	60	0		-12			1508	
30	60	0		-13			1723	

Tolerances for axial internal clearance and preload for angular contact ball bearings of universal design fitted in pairs in X and O arrangements [μm]					
Bore code	Tolerance classes	Series 70B, 72B		Series 73B	
		PN, P6	P5	PN, P6	P5
00 to 09		+8	+6	+8	+6
10 and 11		+8	+6	+12	+10
12 to 34		+12	+10	+12	+10

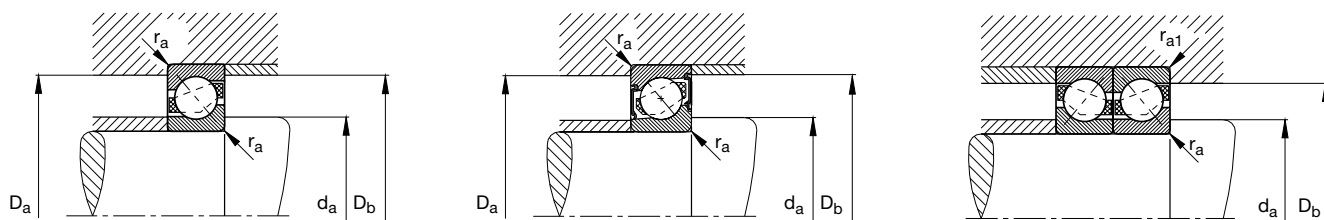
Single row FAG angular contact ball bearings

X-life



Single row FAG angular contact ball bearings, d = 20–30 mm

Shaft	Dimensions											Mass ≈ kg	Basic load ratings	
	d	D	B	r	r ₁	a	D ₁	D ₂	D ₃	d ₁	d ₂		dyn. C _r	stat. C _{0r}
	mm			min	min	≈	≈	≈	≈	≈	≈		N	
20	20	42	12	0.6	0.3	11.6	34.7			29.1		0.06	13400	7500
	20	42	12	0.6	0.3	11.6	35.4	37.1	40.9	28.9	25.9	0.061	13400	7500
	20	47	14	1	0.6	21	36.6			30.4		0.104	13400	7650
	20	47	14	1	0.6	21	36.6			30.4		0.111	13400	7650
	20	47	14	1	0.6	21	36.6			30.4		0.118	13400	7650
	20	47	14	1	0.6	21	37	39.1	43	30.5	26.8	0.108	13400	7650
	20	52	15	1.1	0.6	23	39.9			32.4		0.143	19000	10400
	20	52	15	1.1	0.6	23	39.9			32.4		0.152	19000	10400
	20	52	15	1.1	0.6	23	39.9			32.4		0.156	17600	9500
	20	52	15	1.1	0.6	23	39.7	41.4	47.1	33	30	0.143	19000	10400
25	25	47	12	0.6	0.3	21	39.7			34.1		0.071	15000	9300
	25	47	12	0.6	0.3	21	39.8	41.5	45.9	33.9	30.9	0.071	15000	9300
	25	52	15	1	0.6	24	41.6			35.4		0.127	14600	9300
	25	52	15	1	0.6	24	41.6			35.4		0.135	14600	9300
	25	52	15	1	0.6	24	41.6			35.4		0.138	14000	8650
	25	52	15	1	0.6	24	42	44.1	48	35.5	31.8	0.127	14600	9300
	25	62	17	1.1	0.6	27	48.1			39.3		0.223	26000	15000
	25	62	17	1.1	0.6	27	48.1			39.3		0.242	26000	15000
	25	62	17	1.1	0.6	27	48.1			39.3		0.242	24500	13700
	25	62	17	1.1	0.6	27	48.1	50.4	57.1	39.5	36.2	0.231	26000	15000
30	30	55	13	1	0.6	24.3	46.9			40.7		0.109	18300	12500
	30	55	13	1	0.6	24.3	47.1	48.8	53.6	41.3	38.2	0.109	18300	12500
	30	62	16	1	0.6	27	49.8			42.8		0.196	20400	13400
	30	62	16	1	0.6	27	49.8			42.8		0.202	20400	13400
	30	62	16	1	0.6	27	49.8			42.8		0.213	19600	12500
	30	62	16	1	0.6	27	49.8	51.9	57	43.1	39.5	0.203	20400	13400
	30	72	19	1.1	0.6	31	56			46.5		0.341	32500	20000
	30	72	19	1.1	0.6	31	56			46.5		0.362	32500	20000
	30	72	19	1.1	0.6	31	56			46.5		0.37	30500	18300
	30	72	19	1.1	0.6	31	56	58.6	65.9	46.8	42.7	0.341	32500	20000

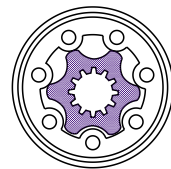


Fatigue limit load C_{ur}	Limiting speed	Reference speed	Designation	Mounting dimensions				
			Bearing	d_a min mm	D_a max	D_b max	r_a max	r_{a1} max
N	min^{-1}		FAG					
475	18000		7004B.TVP	23.2	38.8	40	0.6	0.3
475	9500		7004B.2RS.TVP	23.2	38.8	40	0.6	0.3
530	18000	18000	7204B.TVP	25.6	41.4	42.8	1	0.6
530	18000	18000	7204B.JP	25.6	41.4	42.8	1	0.6
530	28000	18000	7204B.MP	25.6	41.4	42.8	1	0.6
530	9000		7204B.2RS.TVP	25.6	41.4	42.8	1	0.6
750	17000	13000	7304B.TVP	27	45	47.8	1	0.6
750	17000	13000	7304B.JP	27	45	47.8	1	0.6
680	28000	14000	7304B.MP	27	45	47.8	1	0.6
750	8500		7304B.2RS.TVP	27	45	47.8	1	0.6
590	16000		7005B.TVP	28.2	43.8	45	0.6	0.3
590	8000		7005B.2RS.TVP	28.2	43.8	45	0.6	0.3
610	16000	16000	7205B.TVP	30.6	46.4	47.8	1	0.6
610	16000	16000	7205B.JP	30.6	46.4	47.8	1	0.6
570	26000	16000	7205B.MP	30.6	46.4	47.8	1	0.6
610	8000		7205B.2RS.TVP	30.6	46.4	47.8	1	0.6
1070	14000	11000	7305B.TVP	32	55	57.8	1	0.6
1070	14000	11000	7305B.JP	32	55	57.8	1	0.6
960	22000	12000	7305B.MP	32	55	57.8	1	0.6
1070	7000		7305B.2RS.TVP	32	55	57.8	1	0.6
780	14000		7006B.TVP	34.6	50.4	51.8	1	0.6
780	6700		7006B.2RS.TVP	34.6	50.4	51.8	1	0.6
960	13000	13000	7206B.TVP	35.6	56.4	57.8	1	0.6
960	13000	13000	7206B.JP	35.6	56.4	57.8	1	0.6
890	20000	14000	7206B.MP	35.6	56.4	57.8	1	0.6
960	6300		7206B.2RS.TVP	35.6	56.4	57.8	1	0.6
1500	11000	10000	7306B.TVP	37	65	67.8	1	0.6
1500	11000	10000	7306B.JP	37	65	67.8	1	0.6
1360	18000	10000	7306B.MP	37	65	67.8	1	0.6
1500	6000		7306B.2RS.TVP	37	65	67.8	1	0.6

Other designs are also available; please contact us.

Prilog 5: Hidromotor EPM 50

HYDRAULIC MOTORS EPM

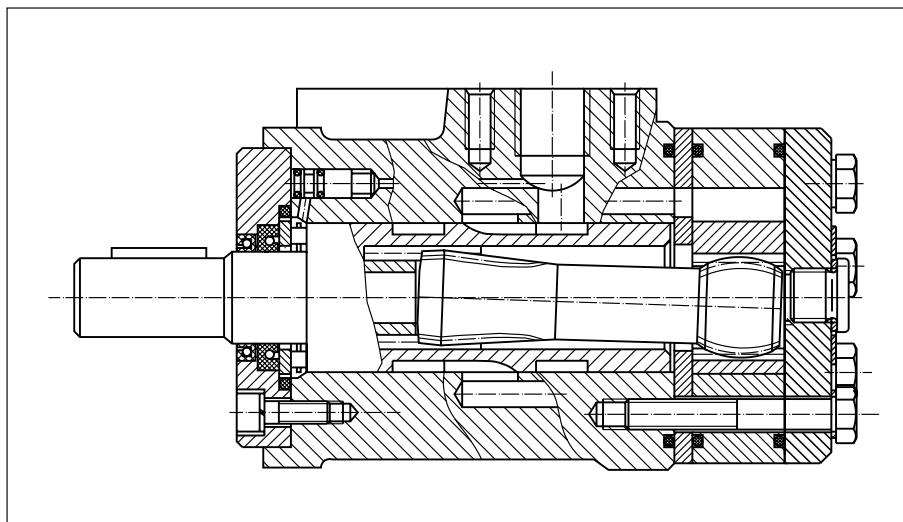


The series of EPM motors have a low speed, high torque capability. Converting hydraulic energy into mechanical energy they are used where the power up to 11 kW is needed.

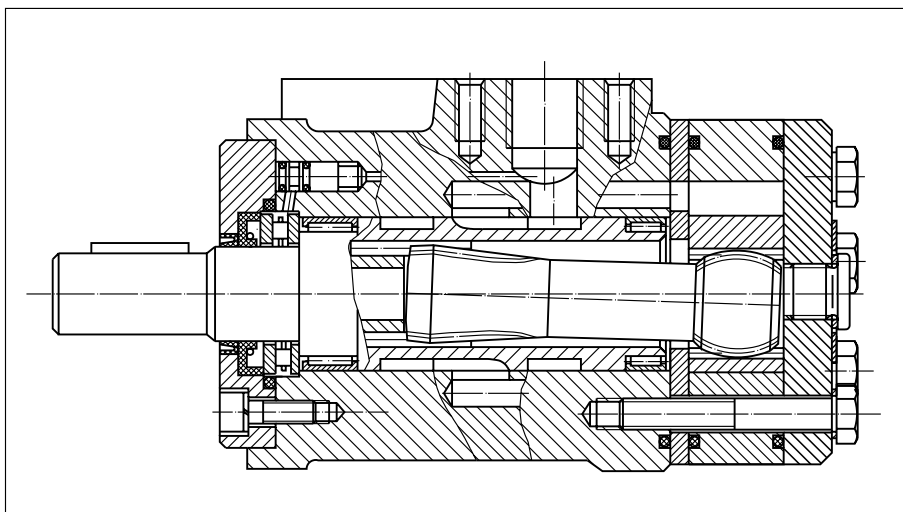
These units provide high output torque from relatively small packages. The motors are available in displacement from 25,0 cm³/rev. to 623,6 cm³/rev. with speeds up to 1500 RPM.

The EPM motors are fixed displacement, gerotor type units that are known for compactness and economy.

All EPM motors have built-in check valves assuring pressure on the shaft seal never exceeds pressure levels seen in the return line.

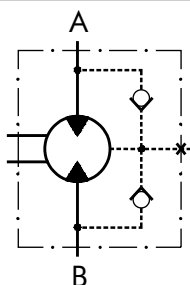


Cutaway of EPM Motor

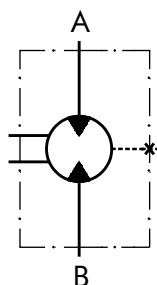


Cutaway of EPMN Motor

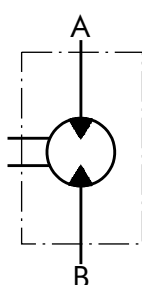
**EPM, EPMW(N)
Series with
Check Valves**



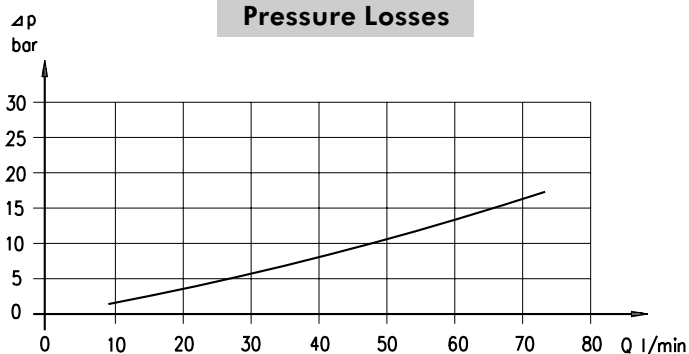
**EPM 25, 32, 40
Series without
Check Valves**



**EPM...U Series
without Check
Valves and Drain**



Pressure Losses



SPECIFICATION DATA

Type	EPM 25	EPM 32	EPM 40	EPM(W) 50	EPM 50...B	EPM(W) 80	EPM 80...B	EPM(W) 100	EPM 100...B
Displacement [cm ³ /rev.]	25	32,0	40,0	49,5	49,5	79,2	79,2	99	99
Max. Speed, [RPM]	cont. 1600	1560	1500	1210	1210	755	755	605	605
	int.* 1800	1720	1750	1515	1515	945	945	755	755
Max. Torque, [daNm]	cont. 3,3	4,3	6,2	9,4	9,4	15,1	15,1	19,3	19,3
	int.* 4,7	6,1	8,2	11,9	11,9	19,5	19,5	23,7	23,7
	peak** 6,7	8,6	10,7	14,3	14,3	22,4	22,4	27,5	27,5
Max. Output, [kW]	cont. 4,5	5,8	8,4	10,1	10,1	10,2	10,2	10,5	10,5
	int.* 6,1	7,8	11,6	12,2	12,2	12,5	12,5	12,8	12,8
Max. Pressure	cont. 100	100	120	140	140	140	140	140	140
Drop, [bar]	int.* 140	140	155	175	175	175	175	175	175
	peak** 225	225	225	225	225	225	225	225	225
Max. Oil Flow, [lpm]	cont. 40	50	60	60	60	60	60	60	60
	int.* 45	55	70	75	75	75	75	75	75
Max. Inlet Pressure, [bar]	cont. 175	175	175	175	175	175	175	175	175
	int.* 200	200	200	200	200	200	200	200	200
	peak** 225	225	225	225	225	225	225	225	225
Max. Return Pressure	cont. 0-100 RPM 150	150	150	150	100	150	100	150	100
	cont. 100-300 RPM 75	75	75	75	30	75	30	75	30
Drain Line or	cont. 300-600 RPM 50	50	50	50	15	50	15	50	15
Max. Pressure in	cont. >600 RPM 20	20	20	20	-	20	-	20	-
Drain Line, [bar]	int.* 0-max RPM 150	150	150	150	100	150	100	150	100
Max. Return Pressure with	cont. 175	175	175	175	175	175	175	175	175
	int.* 200	200	200	200	200	200	200	200	200
Drain Line, [bar]	peak** 225	225	225	225	225	225	225	225	225
Max. Starting Pressure with Unloaded Shaft [bar]	10	10	10	10	10	10	10	10	10
Min. Starting Torque [daNm]	at max. press. drop cont. 3	4	5.4	7,8	7,8	13,2	13,2	16,6	16,6
	at max. press. drop int.* 4.2	5,6	6.9	10	10	16,8	16,8	21	21
Min. Speed [RPM]	20	15	10	10	10	10	10	10	10
Weight [kg]	EPM(F) 5,6	5,6	5,7	5,8		5,9		6,1	
	EPM(F)(E)...B				5,9(6,4)		6(6,5)		6,2(6,7)
	EPMQ(N)			5,2		5,3		5,5	
	EPM(F)(N)E			6,3		6,4		6,6	
	EPMW(N)			5,5		5,6		5,8	
	EPMQ(N)E			5,7		5,8		6,0	

* Intermittent operation: the permissible values may occur for max. 10% of every minute.

** Peak load: the permissible values may occur for max. 1% of every minute.

*** For speeds of 10 RPM or lower, consult factory or your regional manager.

1. Intermittent speed and intermittent pressure drop must not occur simultaneously.

2. Recommended filtration is per ISO cleanliness code 20/16. A nominal filtration of 25 micron or better.

3. Recommended using a premium quality, anti-wear type mineral based hydraulic oil HLP(DIN51524) or HM (ISO 6743/4).
If using synthetic fluids consult the factory for alternative seal materials.

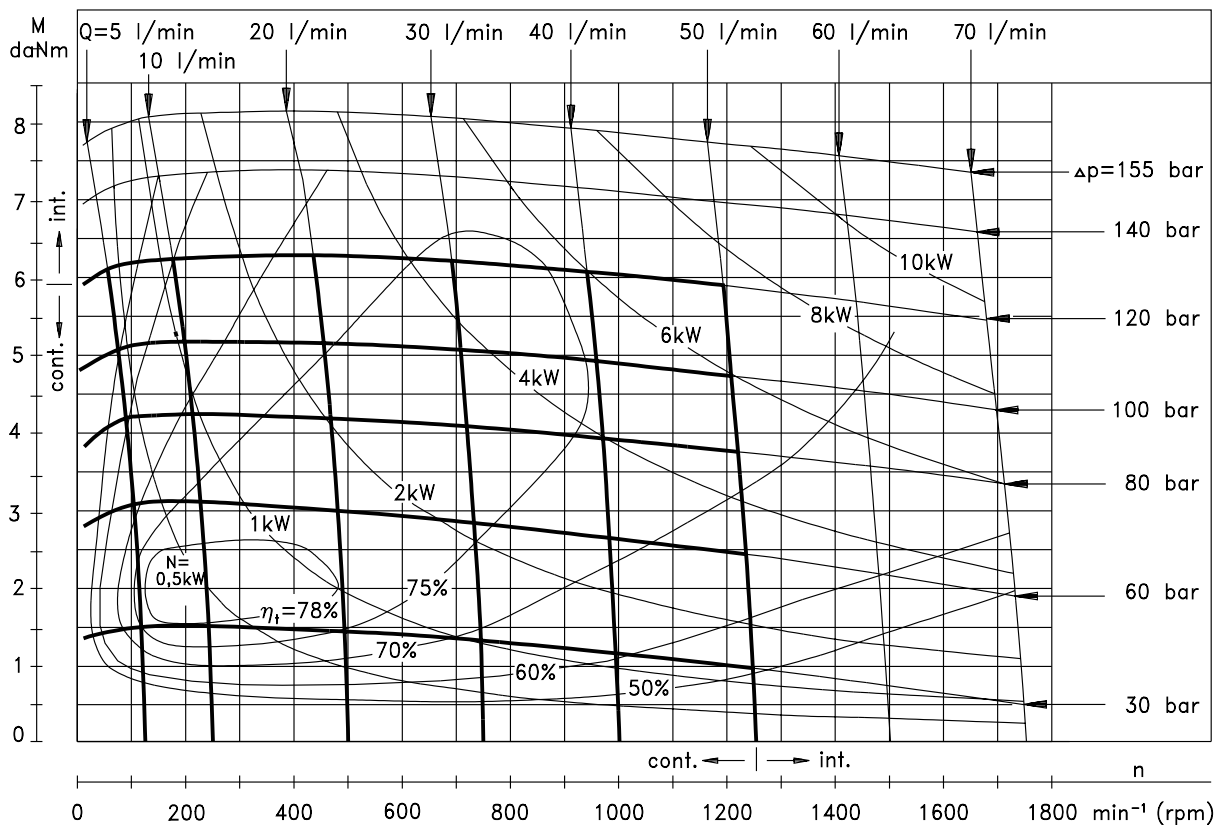
4. Recommended minimum oil viscosity 13 mm²/s at operating temperatures..

5. Recommended maximum system operating temperature is 82°C..

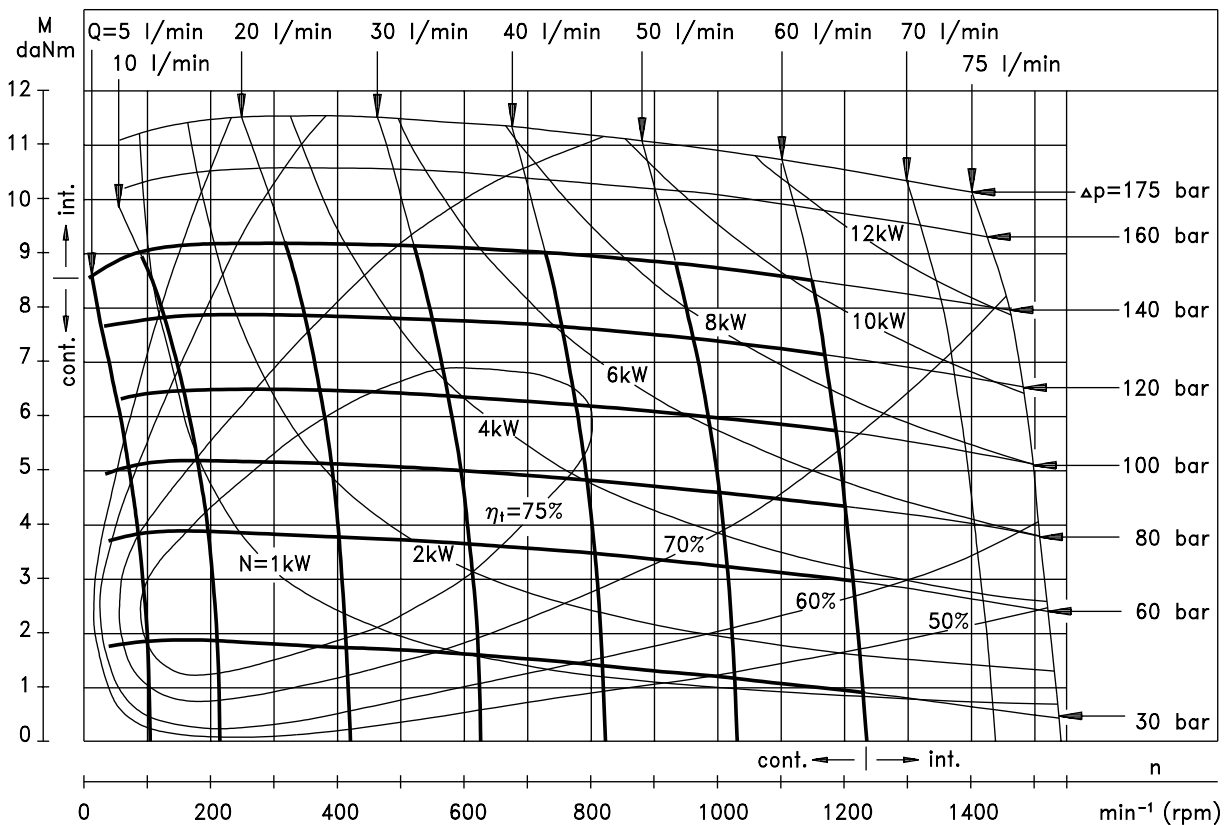
6. To assure optimum motor life fill with fluid prior to loading and run at moderate load and speed for 10-15 minutes.

FUNCTION DIAGRAMS

EPM 40

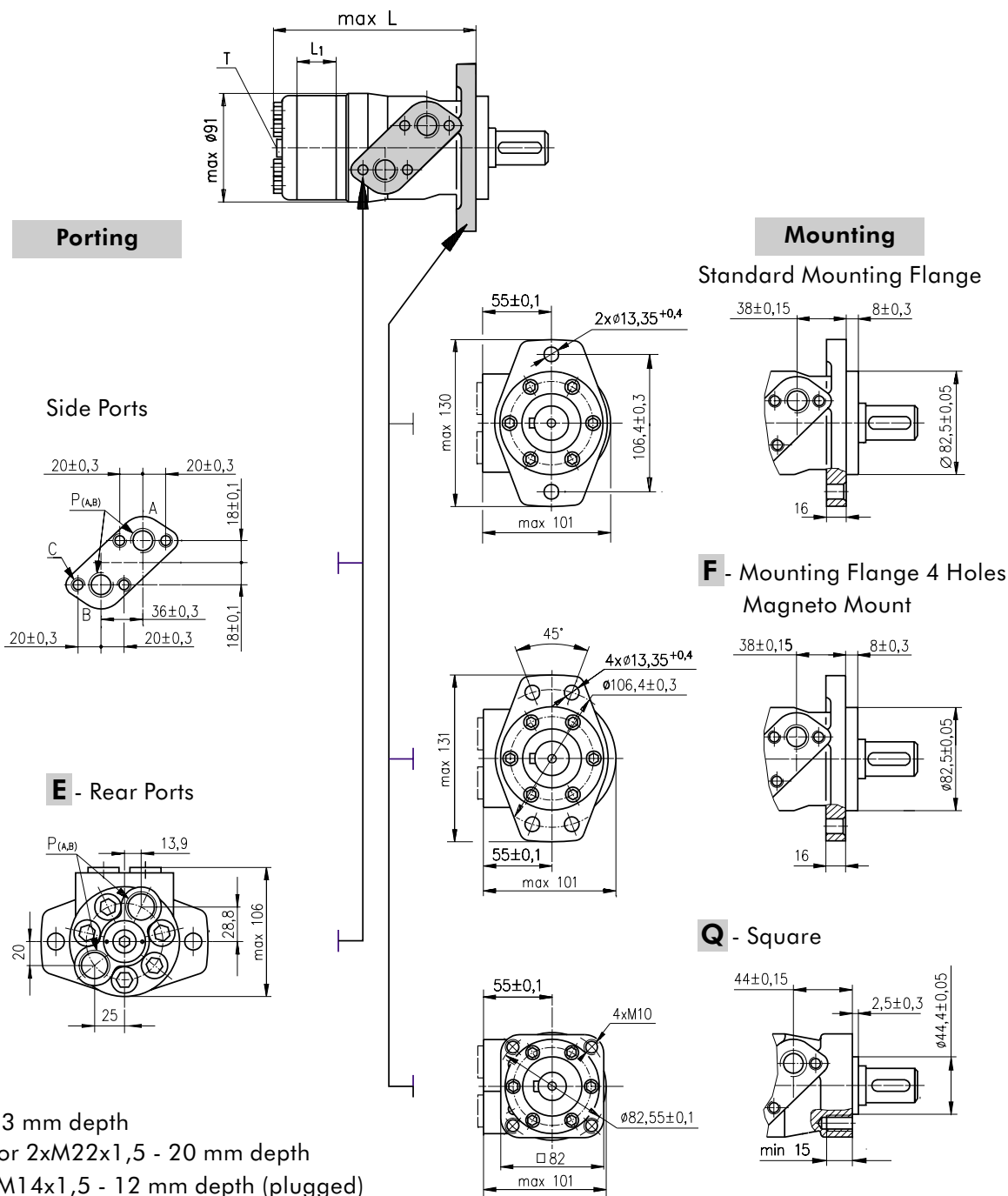


EPM 50



The function diagrams data was collected at back pressure 5 ÷ 10 bar and oil with viscosity of 32 mm^2/s at 50° C.

DIMENSIONS AND MOUNTING DATA




C : 4xM8 - 13 mm depth

P_(A, B): 2xG1/2 or 2xM22x1,5 - 20 mm depth

T : G1/4 or M14x1,5 - 12 mm depth (plugged)

Type	L, mm	Type	L, mm	Type	L, mm	Type	L, mm	L ₁ , mm
EPM(F) 25	133,2	EPMQ 25	139,4	EPM(F)E 25	151,2	EPMQE 25	157,4	4,60
EPM(F) 32	134,5	EPMQ 32	140,7	EPM(F)E 32	152,5	EPMQE 32	158,7	5,90
EPM(F) 40	135,2	EPMQ 40	141,4	EPM(F)E 40	153,2	EPMQE 40	159,4	7,40
EPM(F) 50	135,6	EPMQ 50	141,8	EPM(F)E 50	155,8	EPMQE 50	162,0	6,67
EPM(F) 80	139,6	EPMQ 80	145,8	EPM(F)E 80	159,8	EPMQE 80	166,0	10,67
EPM(F) 100	142,2	EPMQ 100	148,4	EPM(F)E 100	162,4	EPMQE 100	168,6	13,33
EPM(F) 125	145,6	EPMQ 125	151,8	EPM(F)E 125	165,8	EPMQE 125	172,0	16,67
EPM(F) 160	150,2	EPMQ 160	156,4	EPM(F)E 160	170,4	EPMQE 160	176,6	21,33
EPM(F) 200	155,6	EPMQ 200	161,8	EPM(F)E 200	175,8	EPMQE 200	182,0	26,67
EPM(F) 250	162,2	EPMQ 250	168,4	EPM(F)E 250	182,4	EPMQE 250	188,6	33,33
EPM(F) 315	171,6	EPMQ 315	177,8	EPM(F)E 315	191,8	EPMQE 315	198,0	42,67
EPM(F) 400	182,2	EPMQ 400	188,4	EPM(F)E 400	202,4	EPMQE 400	208,6	53,33
EPM(F) 500	193,0	EPMQ 500	199,0	EPM(F)E 500	213,0	EPMQE 500	219,0	66,63
EPM(F) 630	210,5	EPMQ 630	216,5	EPM(F)E 630	230,5	EPMQE 630	236,5	84,00

Prilog 6: Razvodnik PVG 32 specifikacija segmenata

		PVG Specification PVG32				PVG PN 8122014	
						Subsidiary / Dealer:	
						BIBUS Zagreb d.o.o.	
Customer: FSB		Application: KRAN					
Function ↓	A - Port ↓						B - Port ↓
		0 157B5131 PVP p= 160 bar					
PVBZ 10 l/min PVEH	a	157B3171 PVM	1	157B6252 PVBZ	157B9400 PVBS	16	157B4033 PVEH a
	b	157B2001 PVLA					157B2001 PVLA b
	b			LS _A bar	LS _B bar		b
10 l/min PVEH	a	157B3171 PVM	2	157B6210 PVB	157B7000 PVBS	16	157B4033 PVEH a
	b	157B2001 PVLA					157B2001 PVLA b
	b			LS _A bar	LS _B bar		b
10 l/min PVEH	a	157B3171 PVM	3	157B6210 PVB	157B7000 PVBS	16	157B4033 PVEH a
	b	157B2001 PVLA					157B2001 PVLA b
	b			LS _A bar	LS _B bar		b
5 l/min PVEH	a	157B3171 PVM	4	157B6210 PVB	157B7005 PVBS	16	157B4033 PVEH a
	b	157B2001 PVLA					157B2001 PVLA b
	b			LS _A bar	LS _B bar		b
	a		5	157B2014 End plate		16	a
	b						b
	b			LS _A bar	LS _B bar		b
	a		6	157B80004 PVAS		16	a
	b						b
	b			LS _A bar	LS _B bar		b
	a		7			16	a
	b						b
	b			LS _A bar	LS _B bar		b
	a		8			16	a
	b						b
	b			LS _A bar	LS _B bar		b
	a		9			16	a
	b						b
	b			LS _A bar	LS _B bar		b
	a		10			16	a
	b						b
	b			LS _A bar	LS _B bar		b
	a		11			16	a
	b						b
	b			LS _A bar	LS _B bar		b
	a		12			16	a
	b						b
	b			LS _A bar	LS _B bar		b
PAINT			13			b	
BUSINESS TYPE			14				
EAU			15				
Filled in by:		Date: 10.12.2014					
LIST PRICE FOR ABOVE SPEC.							

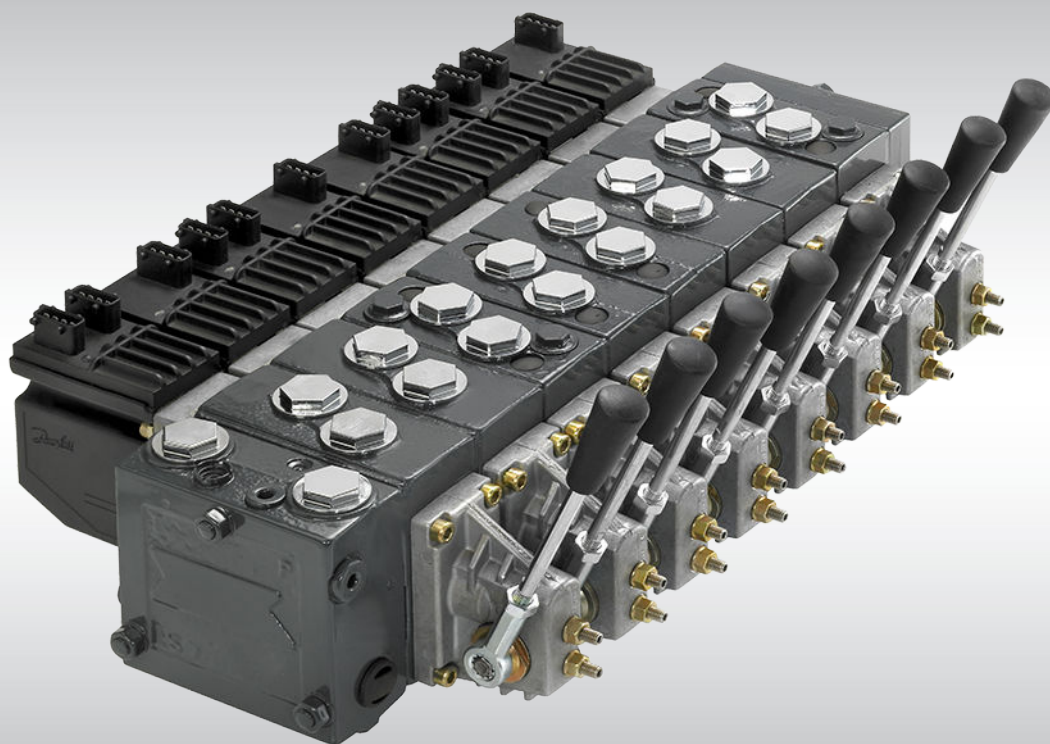
Prilog 7: Razvodnik PVG 32 4 segmenta



Technical Information

Proportional Valve Group

PVG 32



General description

PVG 32 is a hydraulic load sensing valve designed to give maximum flexibility. From a simple load sensing directional valve, to an advanced electrically controlled load-independent proportional valve.

The PVG 32 modular system makes it possible to build up a valve group to meet requirements precisely. The compact external dimensions of the valve remain unchanged whatever combination is specified.

Features of PVG 32

- Load-independent flow control:
 - Oil flow to an individual function is independent of the load pressure of this function
 - Oil flow to one function is independent of the load pressure of other functions
- Good regulation characteristics
- Energy-saving
- Up to 12 basic modules per valve group
- Several types of connection threads
- Low weight
- Compact design and installation



PVG modules

PVP, pump side modules

- Built-in pressure relief valve
- Pressure gauge connection
- Versions:
 - Open center version for systems with fixed displacement pumps
 - Closed center version for systems with variable displacement pumps
 - Pilot oil supply for electrical actuator built into the pump side module
 - Pilot oil supply for hydraulic actuation built into the pump side module
 - Versions prepared for electrical LS unloading valve PVPX

General description

PVB, basic modules

- Interchangeable spools
- Depending on requirements the basic module can be supplied with:
 - Integrated pressure compensator in channel P
 - Load holding check valve in channel P
 - Shock/suction valves for A and B ports
 - LS pressure limiting valves individually adjustable for ports A and B
 - Different interchangeable spool variants
 - All versions suitable for mechanical, hydraulic and electrical actuation

Actuation modules

The basic module is always fitted with mechanical actuator PVM and PVMD, which can be combined with the following as required:

- **Electrical actuator (11 - 32 V ===):**
 - PVES – proportional, Super
 - **PVEH – proportional, High performance**
 - PVEH-F – proportional high performance, Float
 - PVEA – proportional low hysteresis
 - PVEM – proportional, Medium performance
 - PVEO – ON/OFF
 - PVEU – proportional, voltage control, 0-10 V
 - PVED-CC – Digital CAN controlled J1939/ISOBUS
 - PVED-CX – Digital CAN controlled CANopen X-tra safety
 - PVEP – PWM voltage controlled (11-32 V)
 - PVHC – High Current actuator for PVG
- PVMR, cover for Mechanical detent
- PVMF, cover for Mechanical Float
- PVH, cover for Hydraulic actuation

Remote control units

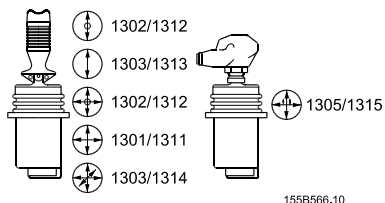
- Electrical remote control units:

<ul style="list-style-type: none"> — PVRE, PVRET — PVREL — PVRES — Prof 1 — Prof 1 CIP — JS120 	<ul style="list-style-type: none"> — JS1000 Ball grip — JS1000 PRO grip — JS2000 — JS6000 — JS7000
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- Hydraulic remote control unit: PVRHH

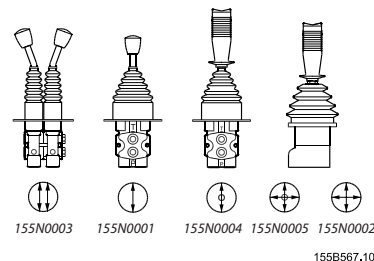
General description

Electrical and hydraulic remote control units

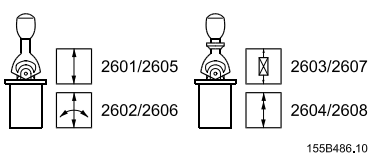
PVRE, electrical control unit, 162F...



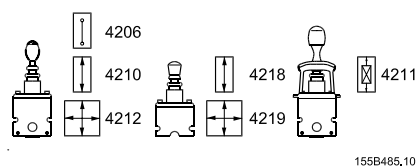
PVRH, hydraulic control unit, 155N...



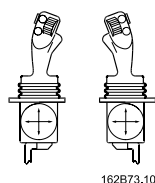
PVREL, electrical control unit, 155U...



PVRES, electrical control unit, 155B...



Prof 1, 162F...



PVG 32 with open center PVP (fixed displ. pump) • PVB with flow control spool

When the pump is started and the main spools in the individual basic modules (11) are in the neutral position, oil flows from the pump, through connection P, across the pressure adjustment spool (6) to tank. The oil flow led across the pressure adjustment spool determines the pump pressure (stand-by pressure).

When one or more of the main spools are actuated, the highest load pressure is fed through the shuttle valve circuit (10) to the spring chamber behind the pressure adjustment spool (6), and completely or partially closes the connection to tank to maintain pump pressure.

Pump pressure is applied to the right-hand side of the pressure adjustment spool (6).

The pressure relief valve (1) will open should the load pressure exceed the set value, diverting pump flow back to tank.

In a pressure-compensated basic module the compensator (14) maintains a constant pressure drop across the main spool – both when the load changes and when a module with a higher load pressure is actuated.

With a non pressure-compensated basic module incorporating a load drop check valve (18) in channel P, the check valve prevents return oil flow.

The basic module can be supplied without the load drop check valve in channel P for functions with over-center valves.

The shock valves PVLP (13) with fixed setting and the suction valves PVLA (17) on ports A and B are used for the protection of the individual working function against overload and/or cavitation.

An adjustable LS pressure limiting valve (12) can be built into the A and B ports of pressure-compensated basic modules to limit the pressure from the individual working functions.

General description

Please see the sectional drawing below for better understanding of this example.

The LS pressure limiting valves save energy compared with the shock valves PVLP:

- with PVLP all the oil flow to the working function will be led across the combined shock and suction valves to tank if the pressure exceeds the fixed setting.
- with LS pressure limiting valves an oil flow of about 2 l/min [0.5 US gal/min] will be led across the LS pressure limiting valve to tank if the pressure exceeds the valve setting.

PVG 32 with closed center PVP (variable displ. pump) • PVB with flow control spool

In the closed center version of PVP an orifice (5) and a plug (7) have been fitted instead of the plug (4).

This means that the pressure adjustment spool (6) will only open to tank when the pressure in channel P exceeds the set value of the pressure relief valve (1).

In load sensing systems the load pressure is led to the pump control via the LS connection (8).

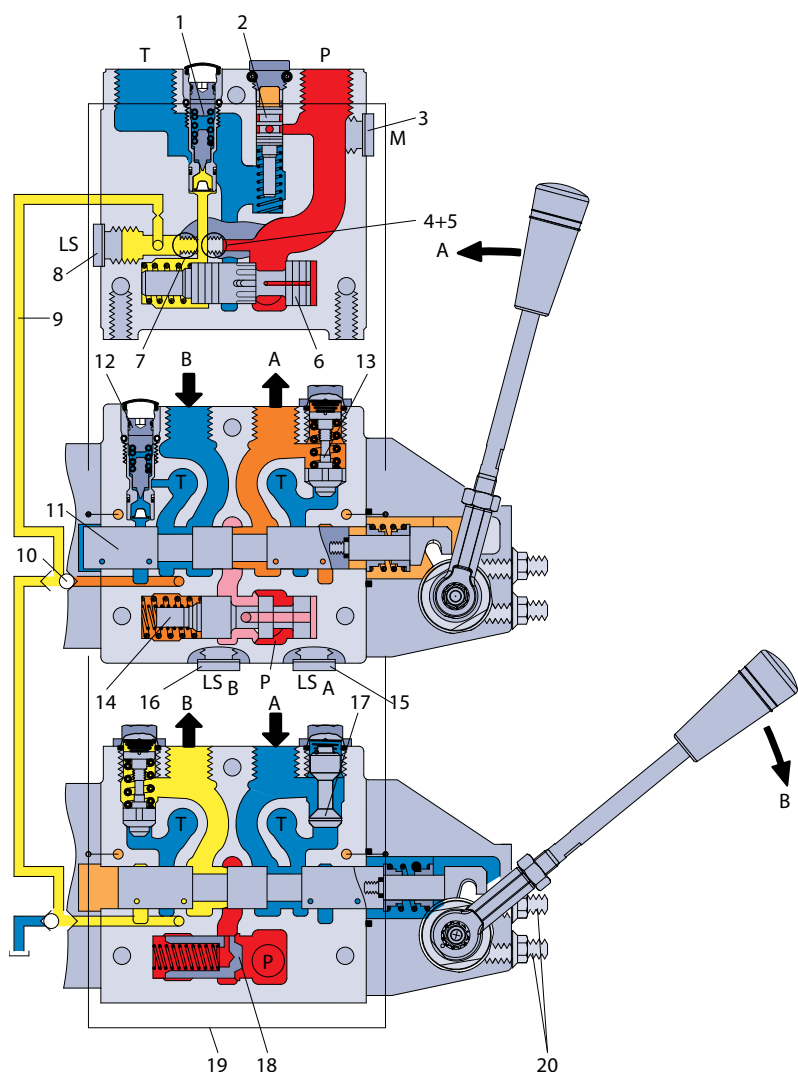
In the neutral position the pump load sense control sets the displacement so that leakage in the system is compensated, to maintain the set stand-by pressure.

When a main spool is actuated the pump load sense control will adjust the displacement so that the set differential pressure (margin) between P and LS is maintained.

The pressure relief valve (1) in PVP should be set at a pressure of approx. 30 bar [435 psi] above maximum system pressure (set on the pump or external pressure relief valve).

General description

PVG 32 sectional drawing



V310106.A

- | | |
|---|--|
| 1 – Pressure relief valve | 11 – Main spool |
| 2 – Pressure reduction valve for pilot oil supply | 12 – LS pressure limiting valve |
| 3 – Pressure gauge connection | 13 – Shock and suction valve, PVLP |
| 4 – Plug, open center | 14 – Pressure compensator |
| 5 – Orifice, closed center | 15 – LS connection, port A |
| 6 – Pressure adjustment spool | 16 – LS connection, port B |
| 7 – Plug, closed center | 17 – Suction valve, PVLA |
| 8 – LS connection | 18 – Load drop check valve |
| 9 – LS signal | 19 – Pilot oil supply for PVE |
| 10 – Shuttle valve | 20 – Max. oil flow adjustment screws for A/B ports |

General description

Load sensing for variable displ. pump supply

The pump receives fluid directly from the reservoir through the inlet line. A screen in the inlet line protects the pump from large contaminants.

The pump outlet feeds directional control valves such as PVG-32, hydraulic integrated circuits (HIC), and other types of control valves.

The PVG valve directs and controls pump flow to cylinders, motors and other work functions. A heat exchanger cools the fluid returning from the valve. A filter cleans the fluid before it returns to the reservoir.

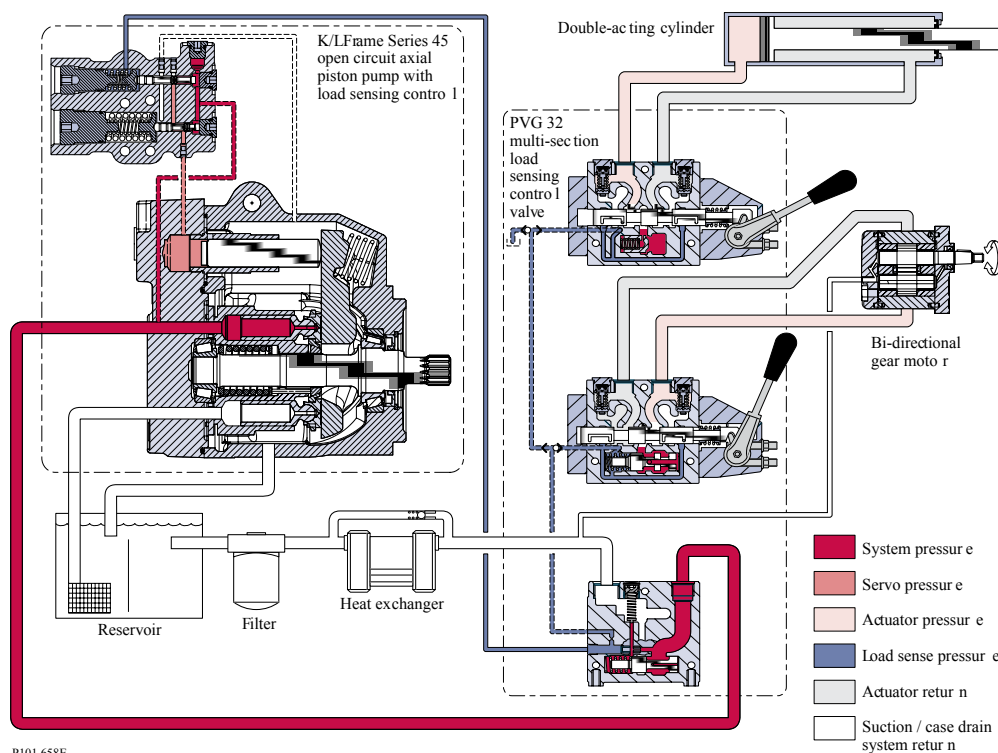
Flow in the circuit determines the speed of the actuators. The position of the PVG valve spool determines the flow demand. A hydraulic pressure signal (LS signal) communicates demand to the pump control.

The pump control monitors the pressure differential between pump outlet and the LS signal, and regulates servo pressure to control the swashplate angle. Swashplate angle determines pump flow.

Actuator load determines system pressure. The pump control monitors system pressure and will decrease the swashplate angle to reduce flow if system pressure reaches the pump control setting.

A secondary system relief valve in the PVG valve acts as a back-up to control system pressure.

Pictorial circuit diagram



P101 658E

Function

It is not recommended to use shock valves as pressure limiting valves in connection with pressure control spools.

Sizing

The size of "half" (e.g. P - A = flow control P - B pressure control) pressure control spools is determined on basis of max. flow demand on the lifting port. If e.g. a max. pressure compensated flow of 65 l/min for the lifting movement, you choose a 65 l/min spool (size D). The metering characteristic has then a given size. As it is often requested to limit the use of the crane boom for downward push/force mode and the LS pressure limitation can be used. It will appear from the characteristics enclosed what effect a pressure limitation, P_{LS} will have on max. flow on the lowering port.

The size for a "full" pressure control spool is determined on basis of known load pressure, P_{LS} max, and requested max. flow.

It will appear from the characteristics enclosed that if the load PLS is low and the pump pressure, P_p , is high as a result of max. stroked spool you will get a large flow.

If P_{LS} is approaching PLS max. the flow will be reduced and the dead band increased. Max. oil flow can be reduced by approx. 50% without limiting max. pressure.

The reduction is made by limiting the spool travel from 7 mm to 5.5 mm.

Limitation

If a pressure controlled spool is chosen for stability reasons consideration should be made to features related to the pressure control principle.

Deadband will change according to the load conditions and the valve section will become load-dependent and that the pump pressure may exceed the load pressure.

With all of the above in mind, a "pressure controlled spool" will minimize oscillation and obtain a stable function that can be controlled smooth and precise.

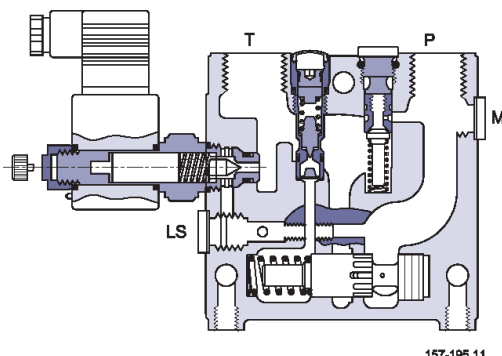
PVPX, electrical LS unloading valve

PVPX is a solenoid LS unloading valve. PVPX is fitted into the pump side module enabling a connection to be made between the LS and the tank lines. Thus the LS signal can be relieved to tank by means of an electric signal.

For a PVP pump side module in open center version the relief to tank of the LS signal means that the pressure in the system is reduced to the sum of the tank port pressure plus the neutral flow pressure for the pump side module.

For a PVP pump side module in closed center version the relief to tank of the LS signal means that the pressure is reduced to the sum of the tank port pressure for the pump side module plus the stand-by pressure of the pump.

PVPX, electrical LS unloading valve



157-195.11

Technical Information PVG 32 Proportional Valve Group

PVG 32 technical data

The characteristics in this catalog are typical measured values. During measuring a mineral based hydraulic oil with a viscosity of 21 mm²/s [102 SUS] at a temperature of 50 °C [122 °F] was used.

PVG 32 technical data

Max. pressure	Port P continuous ¹⁾	350 bar	[5075 psi]
	Port P intermittent ⁵⁾	400 bar	[5800 psi]
	Port A/B continous	350 bar	[5075 psi]
	Port A/B intermittent ⁵⁾	420 bar	[6090 psi]
	Port T, static/dynamic	25/40 bar	[365/580 psi]
Oil flow rated	Port P ^{3) 4)}	140/230 l/min	[37/61 US gal/min]
	Port A/B, with press. comp. ²⁾	100 l/min	[26.4 US gal/min]
	Port A/B witout press. comp.	125 l/min	[33 US gal/min]
Spool travel, standard		± 7 mm	[± 0.28 in]
Spool travel, float position	Proportional range	± 4.8 mm	± 0.19 in]
	Float position	± 8 mm	[± 0.32 in]
Dead band, flow control spools	Standard	±1.5 mm	[± 0.06 in]
	Linear characteristic	± 0.8 mm	[± 0.03 in]
Max. internal leakage at 100 bar [1450 psi] and 21 mm ² /s [102 SUS]	A/B → T without shock valve	20 cm ³ /min	[1.85 in ³ /min]
	A/B → T with shock valve	25 cm ³ /min	[2.15 in ³ /min]
Oil temperature (inlet temperature)	Recommended temperature	30 → 60 °C	[86 → 140 °F]
	Min. temperature	-30 °C	[-22 °F]
	Max. temperature	+90 °C	[194 °F]
Ambient temperature		-30 → 60 °C	[-22 → 140 °F]
Oil viscosity	Operating range	12 - 75 mm ² /s	[65 - 347 SUS]
	Min. viscosity	4 mm ² /s	[39 SUS]
	Max. viscosity	460 mm ² /s	[2128 SUS]
Filtration (See chapter Filtration)	Max. contamination (ISO 4406)	23/19/16	23/19/16
Oil consumption in pilot oil pressure reduction valve		5 l/min	[0.13 US gal/min]

1) With PVSI end plate. With PVS end plate max. 300 bar [4351 psi].

2) For 130 l/min contact Danfoss Product Application Engineering.

3) In open circuit systems with short P-hoses/tubes, attention should be paid to pressure peaks at flows >100 l/min [26.4 US gal/min] .

4) For system with mid inlet PVPVM.

5) Intermittent pressure at max. 250,000 cycles of full PVG life time cycles, with PVSI end plate. The maximum intermittent pressure at max. 250,000 cycles stresses the need to confirm application duty cycle before proceeding with specification. For further information contact Danfoss Product Application Engineering.

Rated Pressure

Product	Maximum continuous P-port pressure
PVG 32 with PVS	300 bar [4351 psi]
PVG 32 with PVSI	350 bar [5076 psi]

Technical Information PVG 32 Proportional Valve Group

PVG 32 technical data

Rated Pressure (continued)

Product	Maximum continuous P-port pressure
PVG 32 with PVBZ	250 bar [3626 psi]
PVG 32 with HIC steel	350 bar [5076 psi]
PVG 32 with HIC aluminium	210 bar [3046 psi]
PVG 120/32 with PVS	300 bar [4351 psi]
PVG 120/32 with PVSI	350 bar [5076 psi]
PVG 100/32 with PVS	300 bar [4351 psi]
PVG 100/32 with PVSI	350 bar [5076 psi]

PVH, hydraulic actuation

Technical data for PVH

Control range pressure	5 – 15 bar [75 – 220 psi]
Max. pilot pressure	30 bar [435 psi]
Max. pressure on port T (The hydraulic remote control lever should be connected directly to tank.)	10 bar [145 psi]

PVM, mechanical actuation

Technical data for PVM

Spool displacement	Operating Torque N·m [lbf·in]				
	PVM + PVMD	PVM + PVE	PVM + PVH	PVM + PVMR	PVM+PVMF
from neutral position	2.2 ±0.2 [19.5 ±1.8]	2.2 ±0.2 [19.5 ±1.8]	2.5 ±0.2 [22.1 ±1.8]	17 [3.8]	22 [5.0]
max. spool travel	2.8 ±0.2 [24.8 ±1.8]	2.8 ±0.2 [24.8 ±1.8]	6.9 ±0.2 [61.0 ±1.8]	–	–
into float position	–	–	–	–	60 [13.5]
away from float position	–	–	–	–	28 [6.3]
from any other position	–	–	–	8.5 [73.3]	–

Control lever position	No	2 × 6
Control range	control lever	±19.5°
	proportional	±13.4°
	float position	22.3°

For PVE please see the PVE, Series 4 for PVG 32/100/120 Technical Information, **520L0553**.

PVE technical data

Technical data for PVEO and PVEM

Supply voltage U _{DC}	rated	12 V _{DC}	24 V _{DC}
	range	11 V to 15 V	22 V to 30 V
	max. ripple	5%	
Current consumption at rated voltage		0.65 A @ 12 V	0.33 A @ 24 V

Technical Information PVG 32 Proportional Valve Group

PVG 32 technical data

Technical data for PVEO and PVEM (continued)

Signal voltage (PVEM)	neutral	0.5 × U _{DC}	
	A-port ↔ B-port	0.25 • U _{DC} to 0.75 • U _{DC}	
Signal current at rated voltage (PVEM)		0.25 mA	0.50 mA
Input impedance in relation to 0.5 • U ^{DC}		12 KΩ	
Power consumption		8 W	

Reaction time for PVEO and PVEM

Supply voltage	Function		PVEO, On/Off	PVEO-R, On/Off	PVEM, Prop. med.
Disconnected by means of neutral switch	Reaction time from neutral position to max. spool travel	max.	0.235 s	0.41 s	0.700 s
		rated	0.180 s	0.35 s	0.450 s
		min.	0.120 s	0.25 s	0.230 s
Disconnected by means of neutral switch	Reaction time from max. spool travel to neutral position	max.	0.175 s	0.33 s	0.175 s
		rated	0.090 s	0.27 s	0.090 s
		min.	0.065 s	0.25 s	0.065 s
Constant voltage	Reaction time from neutral position to max. spool position	max.	-	-	0.700 s
		rated	-	-	0.450 s
		min.	-	-	0.230 s
Constant voltage	Reaction time from max. spool travel to neutral position	max.	-	-	0.700 s
		rated	-	-	0.450 s
		min.	-	-	0.230 s
Hysteresis *		rated	-	-	20%

* Hysteresis (control signal/spool travel) is indicated at rated voltage and f = 0.02 Hz for one cycle.
(one cycle = neutral → full A → full B → neutral)

Technical data for PVEA, PVEH and PVES

PVEA, PVEH and PVES				
Supply voltage U _{DC}		rated	11 V to 32 V	
		range	11 V to 32 V	
		max. ripple	5%	
Current consumption at rated voltage		PVEH/PVES (PVEA)	0.57 (33) A @ 12 V	0.3 (17) A @ 24 V
Signal voltage		neutral	0.5 x U _{DC}	
		A-port ↔ B-port	0.25 • U _{DC} to 0.75 • U _{DC}	
Signal current at rated voltage			0.25 mA to 0.70 mA	
Input impedance in relation to 0.5 • U _{DC}			12 KΩ	
Input capacitor			100 nF	
Power consumption		PVEH/PVES (PVEA)	7 (3.5) W	
(PVEH/PVES)		Max. load	100 mA	60 mA
	Active	Reaction time at fault	500 ms (PVEA: 750 ms)	
	Passive	Reaction time at fault	250 ms (PVEA: 750 ms)	

Technical Information PVG 32 Proportional Valve Group

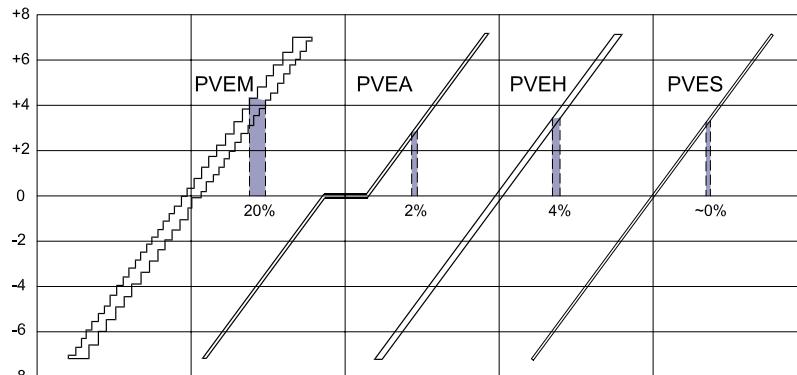
PVG 32 technical data

Reaction time for PVEA, PVEH and PVES

Supply voltage	Function		PVEA Prop. fine s	PVEH Prop. high s	PVES Prop. super s
Disconnected by means of neutral switch	Reaction time from neutral position to max. spool travel	max.	0.50	0.23	0.23
		rated	0.32	0.15	0.15
		min.	0.25	0.12	0.12
Disconnected by means of neutral switch	Reaction time from max. spool travel to neutral position	max.	0.55	0.175	0.175
		rated	0.40	0.09	0.09
		min.	0.30	0.065	0.065
Constant voltage	Reaction time from neutral position to max. spool travel	max.	0.50	0.20	0.20
		rated	0.32	0.12	0.12
		min.	0.25	0.05	0.05
Constant voltage	Reaction time from max. spool travel to neutral position	max.	0.25	0.10	0.10
		rated	0.20	0.09	0.09
		min.	0.15	0.065	0.065
Hysteresis *		rated	2%	4%	~ 0%

Typical hysteresis characteristics for control signal vs spool travel of different PVE types*

Spool position



157-504.10

* Hysteresis (control signal/spool travel) is indicated at rated voltage and $f = 0.02$ Hz. (one cycle = neutral → full A → full B → neutral)

The following technical data are from typical test results. For the hydraulic system a mineral based hydraulic oil with a viscosity of $21 \text{ mm}^2/\text{s}$ [102 SUS] and a temperature of 50°C [122°F] were used.

Pilot oil consumption PVEA, PVEH, PVES, PVEO and PVEM

Function	PVEA Prop. fine	PVEH Prop. high	PVES Prop. super	PVEO ON/OFF	PVEM Prop. medium
Neutral without supply voltage	0	0	0.3 l/min [0.079 US gal/min]	0	0
Locked with supply voltage	0.4 l/min [0.106 US gal/min]	0.1 l/min [0.026 US gal/min]	0.1 l/min [0.026 US gal/min]	0.1 l/min [0.026 US gal/min]	0.1 l/min [0.026 US gal/min]

Technical Information PVG 32 Proportional Valve Group

PVG 32 technical data

Pilot oil consumption PVEA, PVEH, PVES, PVEO and PVEM (continued)

Function	PVEA Prop. fine	PVEH Prop. high	PVES Prop. super	PVEO ON/OFF	PVEM Prop. medium
One actuation (neutral → max) with supply voltage	2 cm ³ [0,12 in ³]				
Continuous actuations with supply voltage	1 l/min [0.26 US gal/min]	0.7 l/min [0.185 US gal/min]	0.8 l/min [0.211 US gal/min]	0.7 l/min [0.185 US gal/min]	0.5 l/min [0.132 US gal/min]

Oil viscosity *	recommended range	12 - 75 mm ² /s	[65 - 347 SUS]
	minimum	4 mm ² /s	[39 SUS]
	maximum	460 mm ² /s	[2128 SUS]
Oil temperature	recommended range	30 - 60°C	[86 - 140°F]
	minimum	-30°C	[-22°F]
	maximum	90°C	[194°F]
Ambient temperature recommended range		-30° → 60°C	[-22° → 140°F]
Filtering in the hydraulic system		Max. allowed degree of contamination: 23/19/16 (ISO 4406, 1999 version)	

* Max. start up viscosity 2500 mm²/s.

PVPX, electrical LS unloading valve

PVPX technical data

Max. operating pressure		350 bar [5075 psi]	
Enclosure to IEC 529		IP65	
Max. pressure drop at an oil flow of 0.1 l/min [2.6 US gal/min]		2 bar [30 psi]	
Oil temperature (Inlet)	Recommended temperature	30°C to 60°C [86°F to 140°F]	
	Min. temperature	-30°C [-22°F]	
	Max. temperature	90°C [194°F]	
Max. coil surface temperature		155°C [311°F]	
Ambient temperature		-30°C to 60°C [-22°F to 140°F]	
Oil viscosity	Operating range	12 to 75 mm ² /s [65 to 347 SUS]	
	Min. viscosity	4 mm ² /s [39 SUS]	
	Max. viscosity	460 mm ² /s [2128 SUS]	
Response time for LS pressure relief		300 ms	
Rated voltage		12 V	24 V
Max. premissible deviation from rated supply voltage		± 10%	
Current consumption at rated voltage	at 22°C [72°F] coil temperature	1.55 A	0.78 A
	at 110°C [230°F] coil temperature	1 A	0.5 A
Power consumption	at 22°C [72°F] coil temperature	19 W	
	at 110°C [230°F] coil temperature	12 W	

Electrical actuation

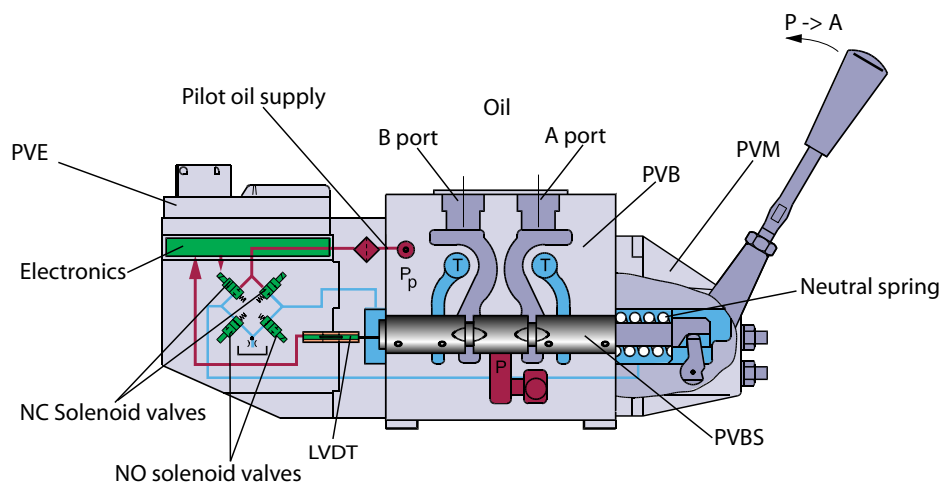
Electrical control of PVG

Valve actuation with electrical actuators has been supported by Danfoss for a long time. The actuation can be controlled directly by joystick, by a PLUS+1® controller or by a broad range of third part controllers. The actuator controls the spool by building up pilot oil pressure on the end of the spool. For the PVE a pilot oil pressure between 10 and 15 bar is used. For the PVHC a pilot oil pressure between 20 and 25 bar is used.

PVG with PVE



Valve section with naming - standard mounted - seen from PVP



V310072.B

A detailed description of the variants is presented in:

*PVE-Series 4 for PVG 32, PVG 100 and PVG 120 Technical Information, **520L0553**, covers all analogue PVE – PVEO, PVEH, PVES, PVEA, PVEM, PVEU, PVEP and the current controlled PVHC.*

*Electrohydraulic Actuator – PVED-CC Series 4 Technical Information, **520L0665**, covers the ISOBUS/SAE J1939 CAN controlled PVED-CC.*

*Electrohydraulic Actuator – PVED-CX Series 4 Technical Information, **11070179**, covers the IEC61508 SIL2 certified CANopen controlled PVED-CX.*

Electrical actuation

- PVEU is available with PVEH and PVES hysteresis
- PVEP, PVED-CC and PVED-CX are available with PVES hysteresis

The standard PVE's are proportional activated actuator except PVEO which is on/off.
 The PVE's have fault-monitoring.

Fault monitoring overview

Type	Fault monitoring	Delay before error out	Error mode	Error output status	Fault output on PVE ¹⁾	LED light	Memory (reset needed)
PVEO PVEM	No fault monitoring	–	–	–	–	–	–
PVEA PVEH PVEP PVES PVEU	Active	500 ms (PVEA: 750 ms)	No fault	Low	< 2 V	Green	Yes
			Input signal faults	High	~U _{DC}	Flashing red	
			Transducer (LVDT)			Constant red	
			Close loop fault				
	Passive	250 ms (PVEA: 750 ms)	No fault	Low	< 2 V	Green	No
			Input signal faults	High	~U _{DC}	Flashing red	
			Transducer (LVDT)			Constant red	
			Close loop fault				
PVE Float six pin	Active	500 ms	Float not active	High	~U _D	Constant red	Yes
		750 ms	Float still active				

1) Measured between fault output pin and ground.

PVEO

The PVEO is an on/off activated actuator. The PVEO has not fault-monitoring.

Variants:

- PVEO-R with a ramp delayed actuation
- PVEO-DI with direction indication feedback
- Anodized aluminum block
- ATEX certified

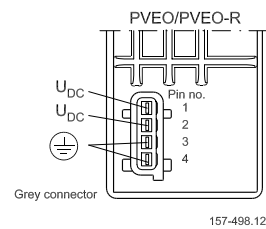
Power supply:

- 12 V
- 24 V

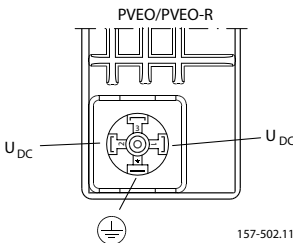
Connectors:

- AMP
- DIN/Hirschmann
- Deutsch

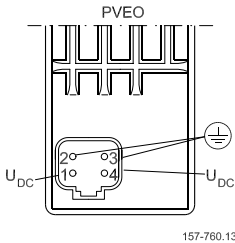
AMP version



DIN/Hirschmann version



Deutsch version



Electrical actuation

PVEM

The PVEM is a proportional activated actuator. The PVEM has not fault-monitoring.

Variants:

- PVEM -R with a ramp delayed actuation
- PVEM for float in B-direction and max. flow B at 4.8 mm

Power supply: 12 / 24 V

Connectors: DIN/Hirshmann

PVEA, PVEH, PVES, PVEU

Variants:

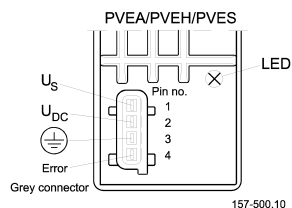
- -F for float in B-direction
max. flow B at 4.8 mm
- -F for float in A-direction
max. flow A at 5.5 mm
- PVES-SP with spool position feedback
- Anodized aluminum block
- ATEX certified

Power supply: 11 → 32 V

Connectors:

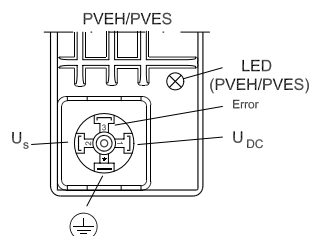
- AMP
- DIN/Hirshmann
- Deutsch

AMP version



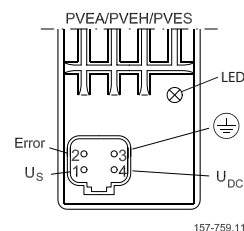
PVEA, PVEH, PVES, PVEU
and PVEH float A

DIN/Hirschmann version



PVEH, PVEM, PVES,
PVEH float B and PVEM float B

Deutsch version



PVEA, PVEH, PVES, PVEU
and PVEH float B

PVEP

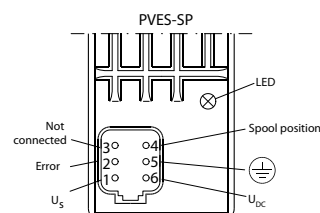
The PVEP is controlled with separate PWM control signals for A and B direction.

The PVEP has hysteresis and fault monitoring like the PVES.

Power supply: 11 → 32 V

Connector: Deutsch

Deutsch version



PVED-CC and PVED-CX

The CAN controlled PVE embedded microcontrollers support the same high spool controllability as the PVES and additionally has high quality feedbacks, safety monitoring and detailed diagnostics.

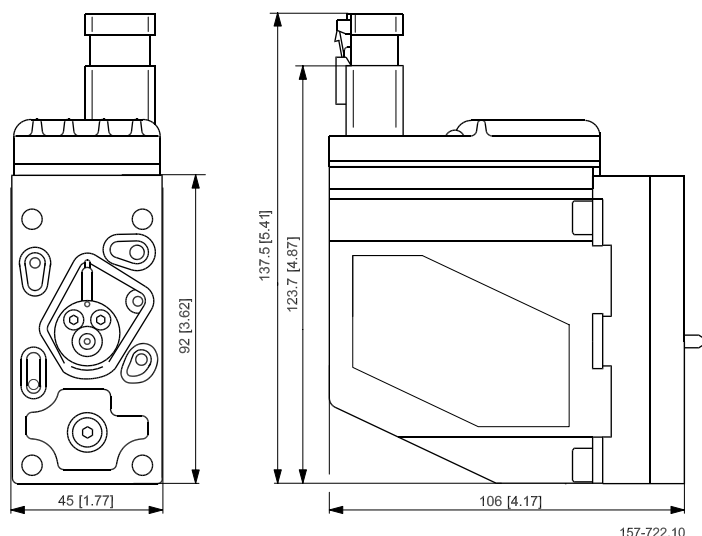
Electrical actuation

PVED has digital communication, that allows a wide range of feedback, setpoint and highly customized settings. CAN bus serial communication makes wiring much easier. Only one cable per PVG group.

Power supply: 11 → 32 V PVE with Deutsch connector incl. female connector

Connectors:

- Deutsch (PVED-CC)
- AMP (PVED-CC and PVED-CX)



For more information on PVED please see the *PVED-CC, Series 4 Technical Information, 520L0665*.

PVHC

For PVG controlled by PVHC, hysteresis is influenced by lever (PVM). The PVHC control is done by dual Pulse Width Modulated (PWM) high current supply 100-400 Hz PWM control signals.

The PVHC does not have neither fault monitoring nor internal closed loop control of the spool.

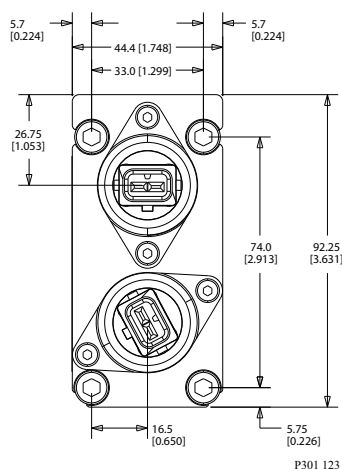
Power supply:

- 12 V
- 24 V

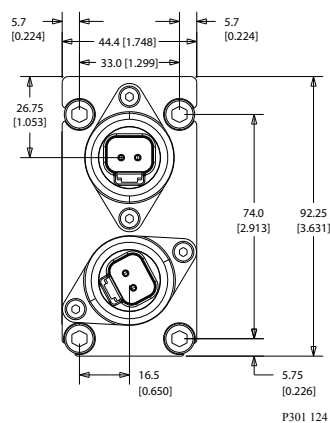
Connectors:

- Deutsch
- AMP

PVHC with AMP version



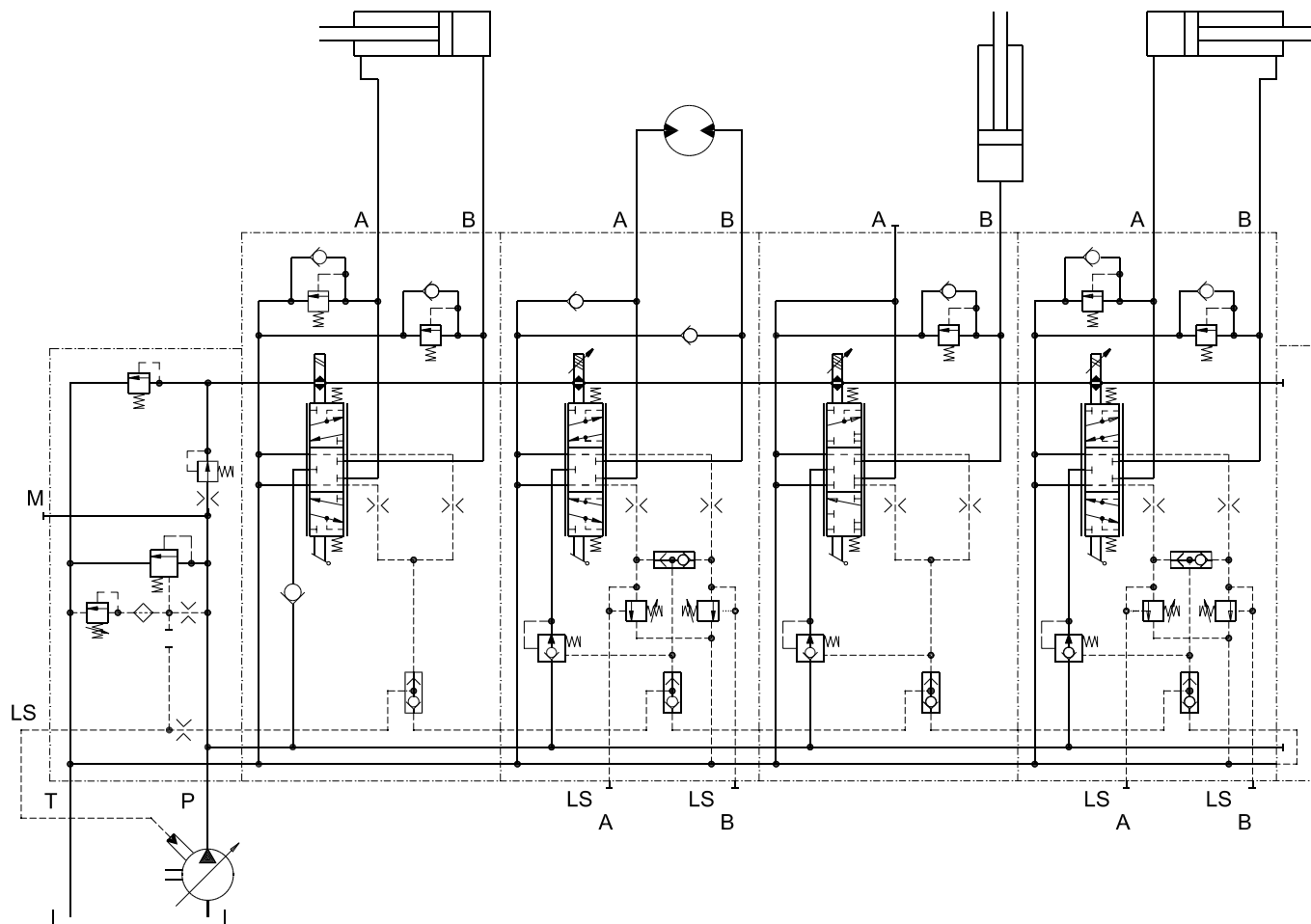
PVHC with Deutsch version



Hydraulic systems

Electrically actuated PVG 32 – variable displ. pump

Example schematic of electrically actuated PVG 32 – variable displacement pump (electrical actuator, shock valves, relief valve)



157-56.10

Other operating conditions

Oil

The main duty of the oil in a hydraulic system is to transfer energy. It must also lubricate the moving parts in hydraulic components, protect them against corrosion, and transport dirt particles and heat out of the system. It is therefore important to choose the correct oil with the correct additives. This gives normal operation and long working life.

Mineral oil

For systems with PVG 32 valves Danfoss recommends the use of mineral-based hydraulic oil containing additives: Type HLP (DIN 51524) or HM (ISO 6743/4).

Non-flammable fluids

Phosphate-esters (HFDR fluids) can be used without special precautions. However, dynamic seals must be replaced with FPM (Viton) seals. Please contact the Danfoss Sales Organization if the PVG 32 valve is to be used with phosphate-esters.

The following fluids should only be used according to agreement with the Danfoss Sales Organization for:

- Water-glycol mixtures (HFC fluids)
- Water-oil emulsions (HFB fluids)
- Oil-water emulsions (HFAE fluids)

Particle content, degree of contamination

Biodegradable oils

PVG 32 valves can be used in systems with rapeseed oil. The use of rapeseed oil is conditioned by:

- complying with the demands on viscosity, water content, temperature and filtering etc. (see chapters below and technical data).
- adapting the operating conditions to the directions of the oil supplier.

Before using other biodegradable fluids, please consult the Danfoss organization. Oil filtration must prevent particle content from exceeding an acceptable level, i.e., an acceptable degree of contamination.

Maximum contamination for PVG 32 is 23/19/16 (see ISO 4406. Calibration in accordance with the ACFTD method). In our experience a degree of contamination of 23/19/16 can be maintained by using a filter fineness as described in the next section.

For more information, please see the Danfoss literature:

- Design Guidelines for Hydraulic Fluid Cleanliness Technical Information, **520L0467**
- Hydraulic Fluids and Lubricants Technical Information, **521L0463**
- Experience with Biodegradable Hydraulic Fluids Technical Information, **521L0465**.

Filtration

Effective filtration is the most important precondition in ensuring that a hydraulic system performs reliably and has a long working life. Filter manufacturers issue instructions and recommendations. It is advisable to follow these.

System filters

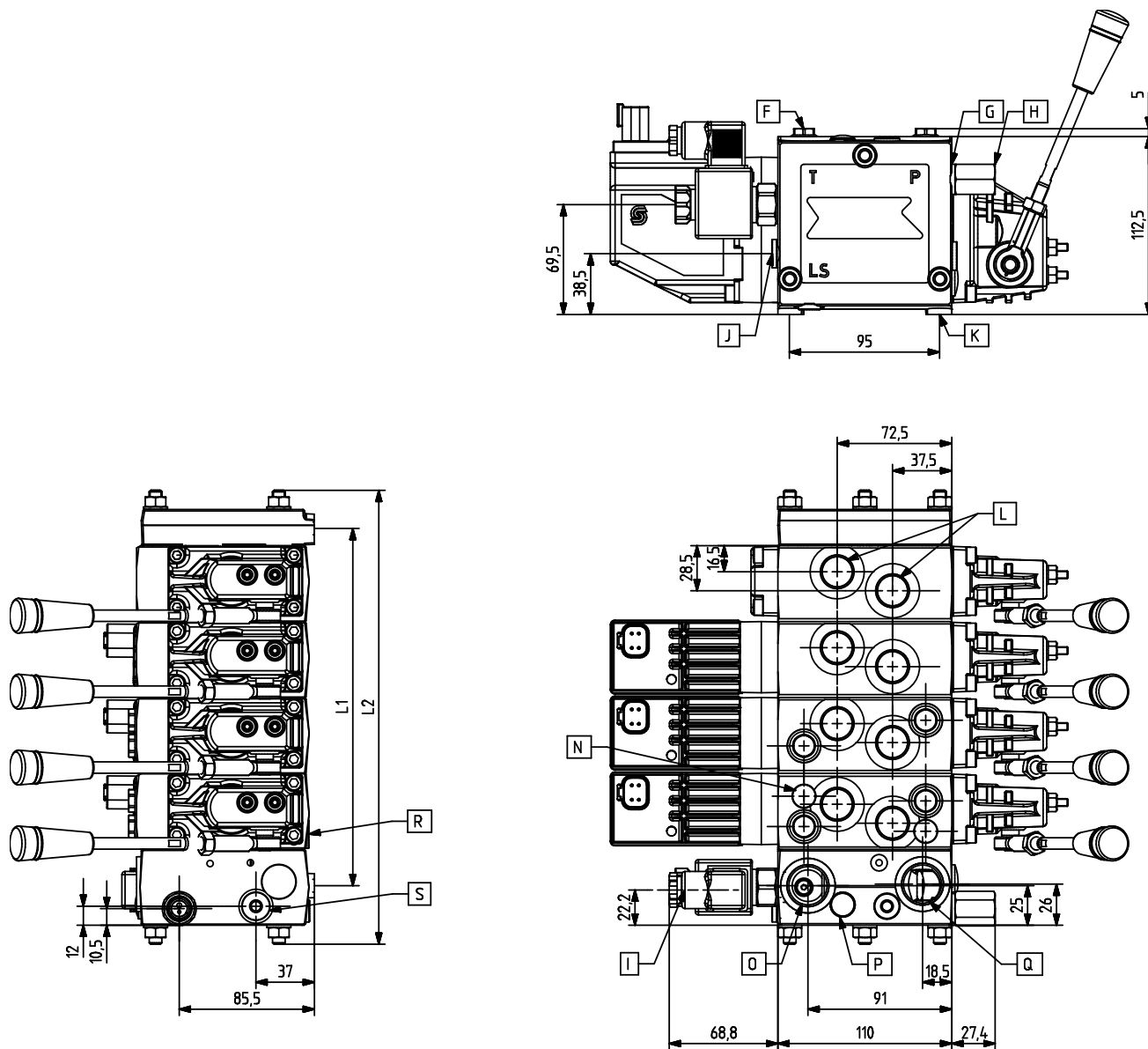
Where demands on safety and reliability are very high a pressure filter with bypass and indicator is recommended. Experience shows that a 10 µm nominal filter (or finer) or a 20 µm absolute filter (or finer) is suitable. It is our experience that a return filter is adequate in a purely mechanically operated valve

Other operating conditions

system. The fineness of a pressure filter must be selected as described by the filter manufacturer so that a particle level of 23/19/16 is not exceeded. The filter must be fitted with pressure gauge or dirt indicator to make it possible to check the condition of the filter. In systems with differential cylinders or accumulators the return filter must be sized to suit the max. return oil flow. Pressure filters must be fitted to suit max. pump oil flow.

Internal filters

The filters built into PVG 32 are not intended to filter the system but to protect important components against large particles. Such particles can appear in the system as a result of pump damage, hose fracture, use of quick-couplings, filter damage, starting up, contamination, etc. The filter in the electrical actuator PVE protecting the solenoid valves has a mesh of 150 µm. Bursting pressure drop for internal filters is 25 bar [360 psi].

Dimensions
PVG 32 Dimensions


V310344.C

F: Shock and suction valve, PVLP

G: Pressure gauge connection: G $\frac{1}{4}$, 12 mm [9/16-18, 0.5 in] deep

H: Plug for external pilot oil supply, PVPC: G $\frac{1}{2}$, 12 mm [$\frac{1}{2}$ -20, 0.47 in] deep

I: Electrical LS unloading valve, PVPX

J: LS connection: G $\frac{1}{4}$, 12 mm [$\frac{1}{2}$ -20; 0.47 in or 9/16-18, 0.5 in] deep

K: Fixing holes: M8 \times min. 10 [5/16-18; 0.39 in] deep

L: Port A and B: G $\frac{1}{2}$, 14 mm [7/8-14; 0.65 in] deep

M: LX connection: PVS; G 1/8, 10 mm [3/8-24; 0.39 in] deep and PVSI; G $\frac{1}{4}$, 12 mm [$\frac{1}{2}$ -20; 0.47 in] deep

Technical Information **PVG 32 Proportional Valve Group**

Dimensions

N: LS pressure limiting valve

O: Tank connection; G $\frac{3}{4}$, 16 mm [1 1/16-12; 0.75 in] deep

P: Pressure relief valve

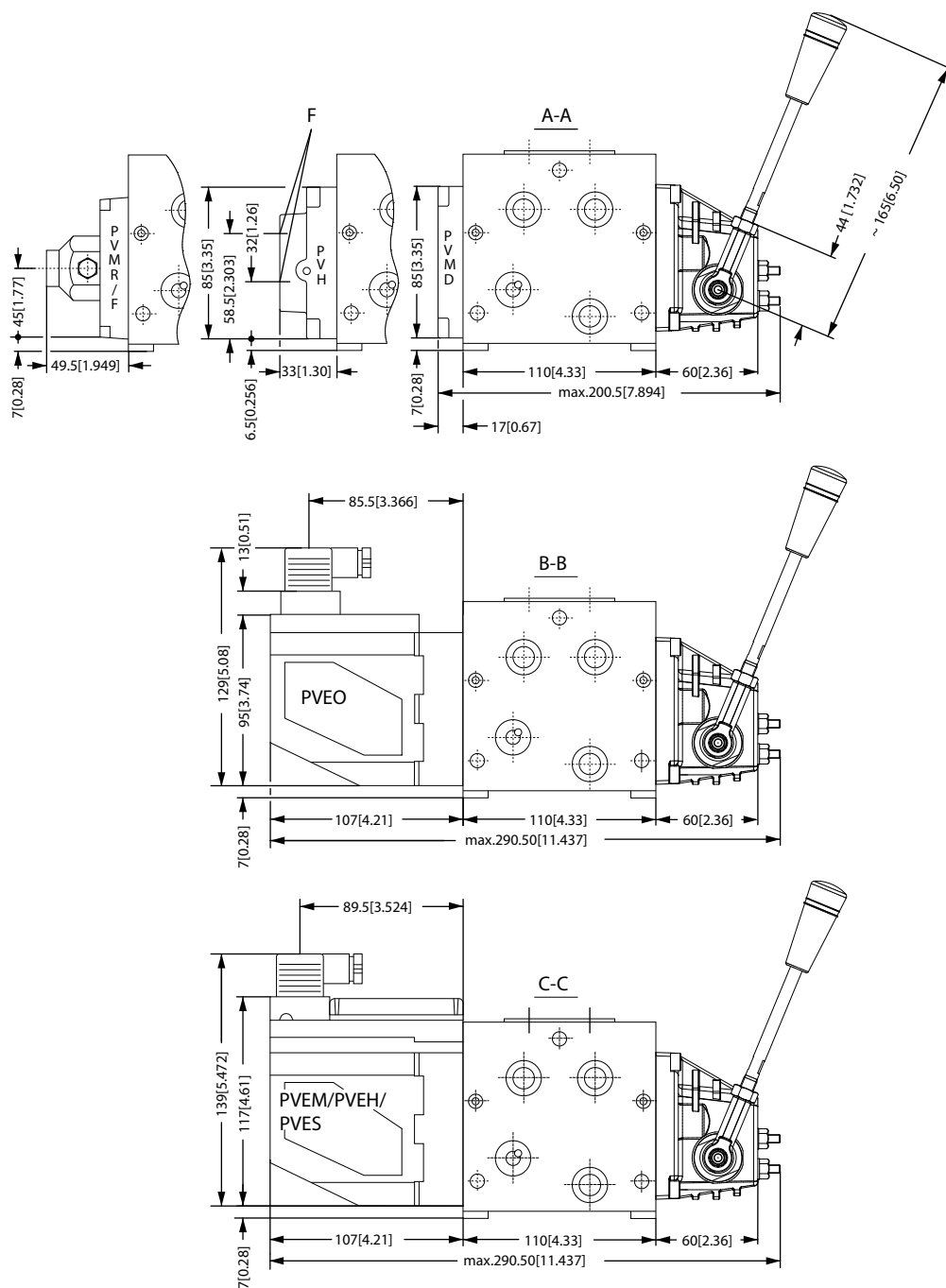
Q: Pump connection; G $\frac{1}{2}$, 14 mm [7/8-14; 0.65 in] deep or G $\frac{3}{4}$, 16 mm [1 1/16-12; 0.75 in] deep

R: LSA and LSB connections; G $\frac{1}{4}$, 12 mm deep [9/16-18, 0.5 in] deep

S : Pp, pilot pressure connection G

PVB		1	2	3	4	5	6	7	8	9	10	11	12
L1	mm	82	130	178	226	274	322	370	418	466	514	562	610
	[in]	[3.23]	[5.12]	[7.01]	[8.90]	[10.79]	[12.68]	[14.57]	[16.46]	[18.35]	[20.24]	[562]	[610]
L2	mm	140	189	238	287	336	385	434	483	527	576	622	670
	[in]	[5.51]	[7.44]	[9.37]	[11.30]	[13.23]	[15.16]	[17.09]	[19.02]	[20.95]	[22.87]	[622]	[670]

Dimensions



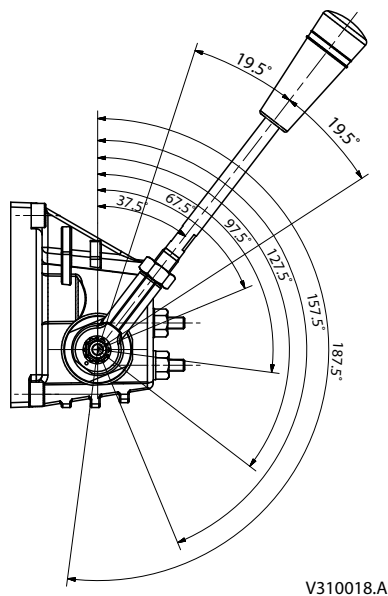
V310141.A

F : G 1/4, 12 mm deep [1/2 in - 20, 0.47 in deep]

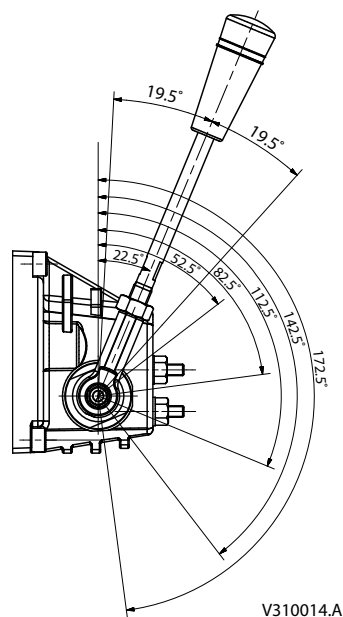
Dimensions

PVM, control lever positions

Base with an angle of 37.5°



Base with an angle of 22.5°



The angle of the handle is determined by which side of the handle that is mount towards the base. If a 22.5° angle is needed the "dot" on the handle is not visible. If 37.5° is needed the dot should be visible.

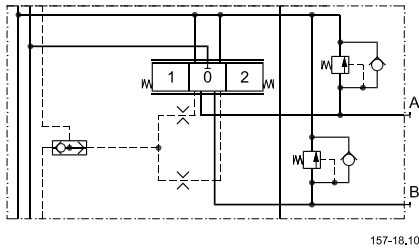
Surface treatment

The PVG valve has as standard, an untreated surface. In certain applications, depend on different factors, such as: salty environment, large temperature changes, high humidity, rust can develop on the surface. This will not affect the performance of the PVG valve group. To prevent/reduce rust development, Danfoss recommend the PVG valve group to be painted. Rust on the surface is not seen as a valid complaint issue, neither on painted or unpainted PVG valve groups.

Technical Information PVG 32 Proportional Valve Group

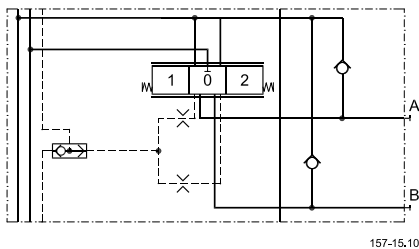
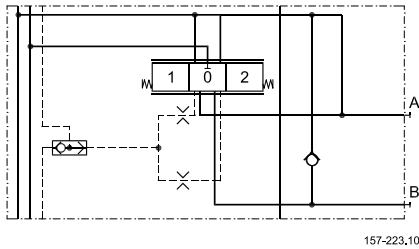
Modules symbols, description and code numbers

PVLP, shock and suction valve

Symbol	Description
	Shock and suction valve for port A and/or B. (Not adjustable). Lifetime 200.000 actuations.

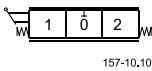
PVLA, suction valve (fitted in PVB)

PVLA, suction valve

Symbol	Description	Code number
	Suction valve for port A and/or B.	157B2001
	Plug for connecting the nonactive port to tank, when using a single acting spool.	157B2002

PVM, mechanical actuation

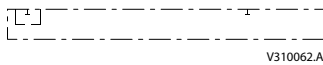
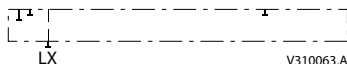
PVM, mechanical actuation

Symbol	Description	Code number with stop screws w/o stop screws	
	PVM, Standard, spring centered Individual oil flow adjustment to ports A and B	157B3171	157B3191
	Without actuation lever and base. Shaft for mounting of actuation lever	157B3173	157B3193
	PVM, as standard, without actuation lever. With base for mounting of actuation lever	157B3174	157B3194
	PVM, Standard, spring. Individual oil flow adjustment to ports A and B. (Anodized)	157B3184	-

Technical Information PVG 32 Proportional Valve Group

Modules symbols, description and code numbers

PVS, end plate (continued)

Symbol	Description	Mounting threads	Code number
 V310062.A	PVSI, without active elements Without connections.	BSP	157B2014
		SAE	157B2004
 V310063.A	PVSI, without active elements LX connections. Max. intermittend LX pressure: 350 bar [5075 psi]	G 1/4 10 mm deep BSP	157B2015
		1/2 in - 20; 0,47 in deep SAE	157B2005

For mounting threats please see the chapter [Dimensions](#).

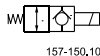
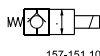

PVAS, assembly kit

PVAS, assembly kit

Code no, 157B...	0	1	2	3	4	5	6	7	8	9	10	11	12
PVB's	8000	8001	8002	8003	8004	8005	8006	8007	8008	8009	8010	8061	8062
PVB + PVPVM	-	8021	8022	8023	8024	8025	8026	8027	8028	8029	8030	8081	8082
Weight kg [lb]	0.1[0.2]	0.15 [0.3]	0.25 [0.6]	0.30 [0.7]	0.40 [0.9]	0.45 [1.0]	0.50 [1.1]	0.60 [1.3]	0.65 [1.4]	0.70 [1.6]	0.80 [1.7]	0.85 [1.8]	0.9 [2.0]

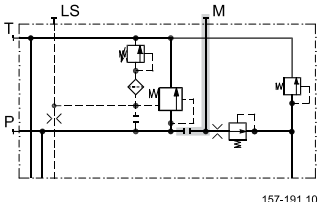
PVPX, electrical LS unloaded valve

PVPX, electrical LS unloaded valve

Symbol	Description		Code number
 157-150,10	PVPX, Normally open: LS pressure relieved with no signal to PVPX	12 V	157B4236
		24 V	157B4238
 157-151,10	PVPX, Normally closed: LS pressure relieved with no signal to PVPX	12 V	157B4246
		24 V	157B4248
 157-152,10	PVPX, Normally open with manual override: LS pressure relieved with no signal to PVPX Manual override DE-selects LS-pump	12 V	157B4256
		24 V	157B4258
-	Plug		157B5601

PVPC, plug for external pilot oil supply

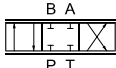
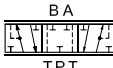
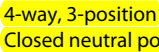
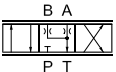
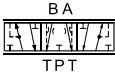
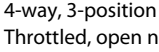
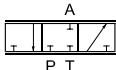
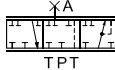
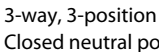
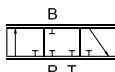
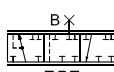
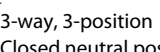
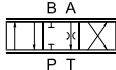

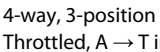
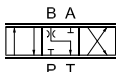

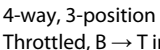
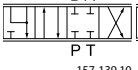

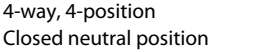
PVPC, plug for external pilot oil supply

Symbol	Description		Code number
 157-191,10	PVP, Plug without check valve for open or closed center	G 1/2, 12 mm deep	157B5400
		1/2 in - 20; 0.47 in deep	-

Technical Information PVG 32 Proportional Valve Group

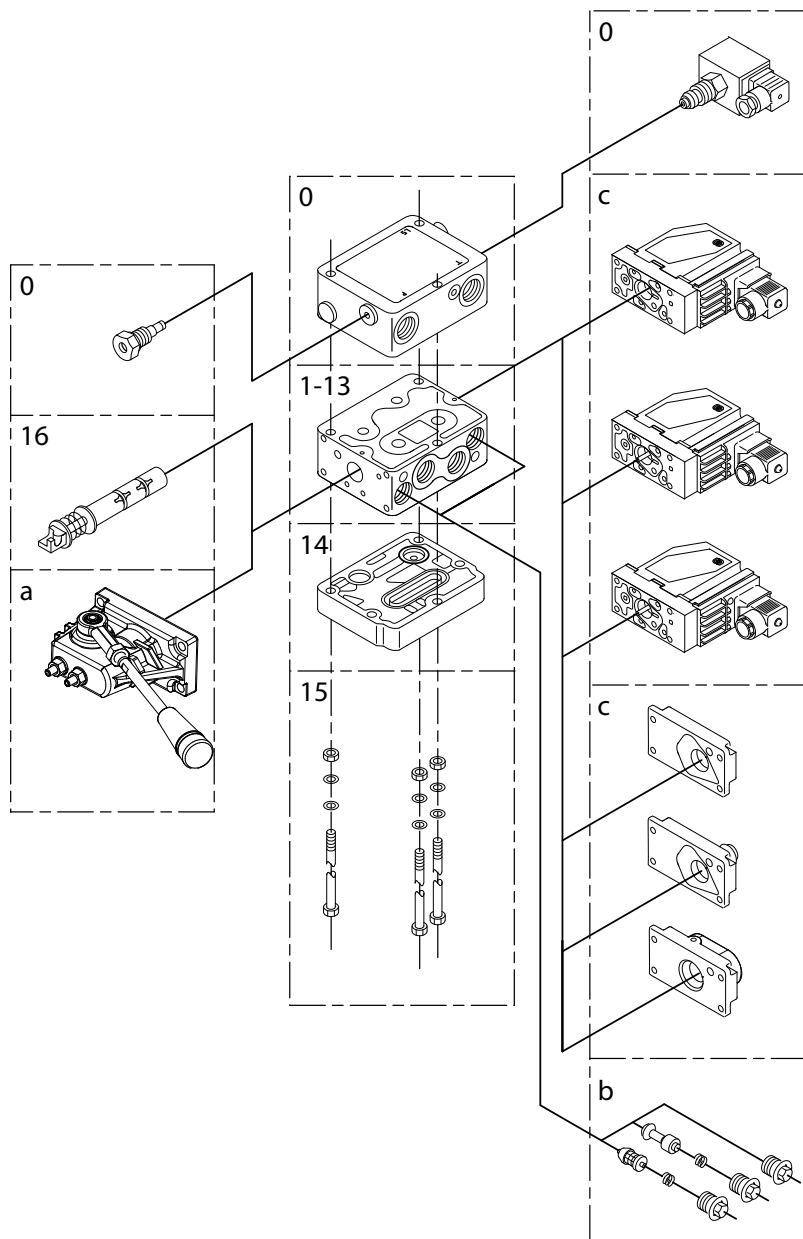
Module selection chart

Standard FC spools

PVB is with LS _{A/B} shuttle valve							Code number 157B....		PVB is without LS _{A/B} shuttle valve						
Press. compensated flow: l/min [US gal/min]							ISO symbol	Symbol	Press. compensated flow l/min [US gal/min]						
F 130 [34.3]	E 100 [26.4]	D 65 [17.2]	C 40 [10.6]	B 25 [6.6]	A 10 [2.6]	AA 5 [1.3]			AA 5 [1.3]	A 10 [2.6]	B 25 [6.6]	C 40 [10.6]	D 65 [17.2]	E 100 [26.4]	F 130 [34.3]
7026	7024	7023	7022	7021	7020	7025	 157-02,10	 157-26,10	7005	7000	7001	7002	7003	7004	7006
							 4-way, 3-position Closed neutral position								
7126	7124	7123	7122	7121	7120	7125	 157-03,10	 157-27,10	7105	7100	7101	7102	7103	7104	7106
							 4-way, 3-position Throttled, open neutral position								
-	-	-	-	-	-	-	 157-04,10	 157-28,10	-	7200	7201	7202	7203	7204	-
							 3-way, 3-position Closed neutral position, P → A								
-	-	-	-	-	-	-	 157-05,10	 157-29,10	-	-	7301	7302	7303	7304	-
							 3-way, 3-position Closed neutral position, P → B								
-	7424	7423	7422	7421	-	-	 157-06,10	 157-30,10	-	-	7401	7402	7403	7404	7406
							 4-way, 3-position Throttled, A → T in neutral position								
-	7524	7523	7522	7521	-	-	 157-07,10	 157-31,10	-	-	7501	7502	7503	7504	-
							 4-way, 3-position Throttled, B → T in neutral position								
-	7624	7623	7622	7621	7620	-	 157-139,10	 157-140,10	-	-	-	-	-	-	-
							 4-way, 4-position Closed neutral position Float P → B → F								

Module selection chart

PVB, basic valves



V310168.A

PVB, basic valves

Description	No facilities for shock valves A and B		Facilities for shock valves A and B	
	G ½	7/8 - 14 UNF	G ½	7/8 - 14 UNF
Without compensator /check valve	157B6000	157B6400	157B6030	157B6430
With check valve	157B6100	157B6500	157B6130	157B6530
With check valve and LSA/B shuttle valve	-	-	157B6136	157B6536
With compensator valve	157B6200	157B6600	157B6230	157B6630

Technical Information PVG 32 Proportional Valve Group

Module selection chart

PVE, electrical actuation

PVE, electrical actuation

Description		Code No.			Weight kg [lb]
		Hirsch	AMP	Deut.	
PVEO, on-off	12 V	157B4216	157B4901	157B4291	0.6 [1.3]
	24 V	157B4228	157B4902	157B4292	
PVEO-R, on/off	12 V	157B4217	157B4903	-	
	24 V	157B4229	157B4904	-	
PVEM, prop. medium – Standard	12 V	157B4116	-	-	0.9 [2.0]
	24 V	157B4128	-	-	
PVEM, prop. medium – Float – > B	12 V	157B4416	-	-	1.0 [2.2]
	24 V	157B4428	-	-	
PVEA, active fault mon.	-	-	157B4734	157B4792	0.9 [2.0]
PVEA, passive fault mon.	-	-	157B4735	-	
PVEA-DI, active fault mon.	-	-	157B4736	157B4796	
PVEA-DI, passive fault mon.	-	-	157B4737	-	1.0 [2.2]
PVEH active fault mon.	-	157B4032	157B4034	157B4092	
PVEH passive fault mon.	-	157B4033	157B4035	157B4093	
PVEH float – > B, act. fault	-	157B4332	-	157B4392	
PVEH float – > A, act. fault	-	-	157B4338	-	
PVEH- DI active fault mon.	-	-	157B4036	157B4096	
PVEH - DI passive fault mon.	-	-	157B4037	-	157B4892
PVES, active fault mon.	-	157B4832	157B4834	-	
PVES, passive fault mon.	-	157B4833	157B4835	-	-

PVMD, PVMR, PVMF, PVH covers

Description	Code No.	Material	Anodized	Weight
				kg [lb]
PVMD Cover for PVB	157B0001	aluminium	no	0.1 [0.2]
	157B0009		yes	
	157B0021	cast iron	N/A	0.9 [2.0]
PVMR (Friction Detent)	157B0004	aluminium	no	0.3 [0.6]
	157B0012		yes	
	157B0024	cast iron	N/A	
PVMF (Mech. float position)	157B0005	aluminium	no	0.2 [0.4]
Hydraulic actuation PVH 9/16-18 UNF	157B0007	aluminium	no	
	157B0010		yes	
	157B0014	cast iron	N/A	
Hydraulic actuation PVH G1/4	157B0008	aluminium	no	0.9 [2.0]
	157B0011		yes	
	157B0016	cast iron	N/A	

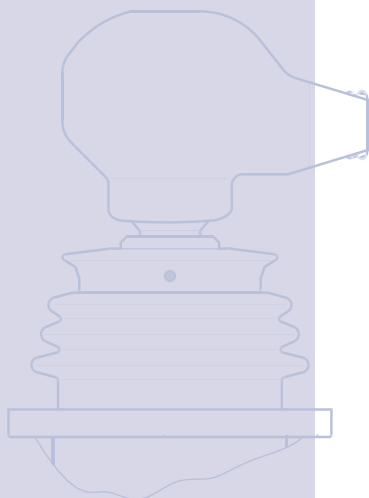
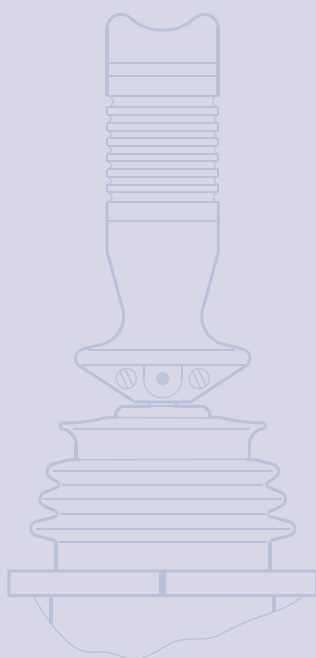
Technical Information PVG 32 Proportional Valve Group

Module selection chart

PVLA, anti-cavitation valve

Description	Code No.	Weight	
		kg	[lb]
Plug A or B	157B2002	0.04	0.09
Valve A or B	157B2001	0.05	0.1

Prilog 8: Joystick Prof 1



Revision History

Table of Revisions

Date	Page	Changed	Rev
Mar 2008	All	First edition	AA
Apr 2010	36	Japan location	AB
Jun 2010	14	Drawing adjusted	AC

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Frontpage: F300 746, F300 747, F300 748, F300 749, Drawing 162B96

Application



F300 749

PVRE, PVRET and Prof joysticks from Sauer-Danfoss are generally used together with PVGs and PVEs, but can be used in any application. A complete range of joysticks from the simple PVRE handle with X-Y functions to the Prof 1 ergonomic handle with rollers and pushbuttons are available.

Mechanical Design

All handle variants share the same mechanical base to which the electronics are mounted. The mounting flange of the joystick is an integrated part of the mechanical base, which also contains a linkage that transfers handle movement to the electronics. The linkage also includes neutral positioning springs.

The neutral positioning springs are designed to ensure a smooth return of the handle into neutral position. The maximum spring force is optimised to be just strong enough to keep the handle in position, even during operation in rough terrain, without interfering with the operation of the joystick or impairing its ergonomic characteristics.

Spring force	8-10 N
--------------	--------

Main Function Module

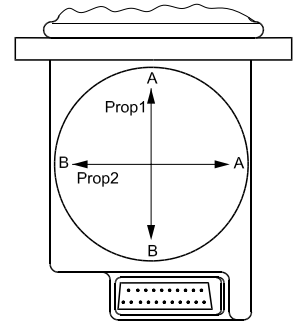
(Prop1 and Prop2)
The primary functions of the joystick are defined as its X and Y directions.

Main functions are potentiometers with integrated direction switches.

Each function has a working angle of $\pm 18^\circ$.

Signal range	Neutral signal
25% – 75%	50%
of supply voltage	

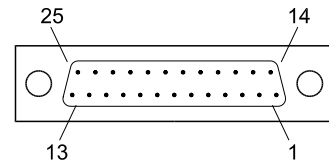
Note: When moving the handle diagonally the maximum signal range is not available.



162B89.10

Connector

All joysticks come with a common **25 pin male SUB-D connector** with M3 screws. (MIL - DTL - 24308)



162B78.11

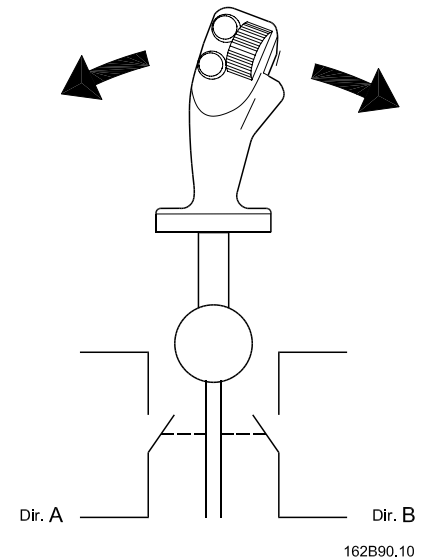
Direction Switches

Proportional modules have integrated direction switches. One switch is activated when the module is moved in the A direction, the other is activated when the module is moved in the B direction.

The direction switches are used to activate the neutral position switch, and with some electronic modules the direction switch outputs are available in the connector. (See details about electronics.)

There is a dead band in the joystick of approximately 1.5° before the direction switches are activated.

Note: The direction switches are independent from the signal voltage



Neutral Position Switch

The neutral position switch can supply up to 3 PVEs or other devices (see electrical details), and functions as both a power save and a safety switch. The switch is only activated when one or more of the proportional modules are activated.

The operation of the neutral position switch is dependant on signals from the direction switches.

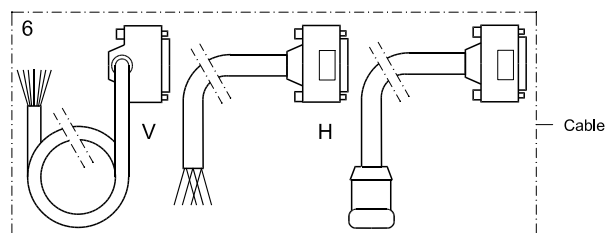
Sauer-Danfoss recommends that the neutral position switch be used to the greatest possible extent.

Note: When using the neutral position switch all three U_{DC} wires as well as all three Neutral Switch wires **must** be connected.

Cables

For compatibility with different applications, a selection of mating cables are available:

Code no. 162B....	Length mm [in]	Plug type	Type
6013	4000 [157]	Leads	Vertical SUB-D
6014	4000 [157]	Leads	Horizontal Sub-D
6015	500 [19]	Clipper	–
6016	230 [9]	TrimTrio	–
6017	230 [9]	Tabs	PVRE compatibility



162B93.10 .10

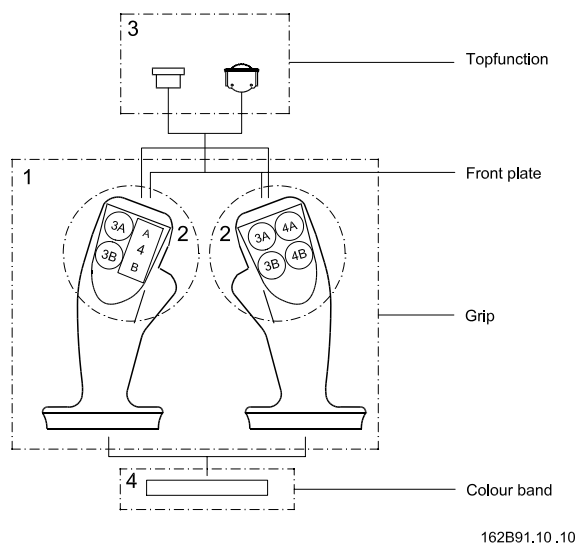
Prof Joysticks

The Prof family of joysticks is built around a series of modules that can be combined in various ways to create the joystick that best fits the application.

Each joystick has a base module with proportional functions (X & Y); a colour band for decoration and identity, a handle, and depending on handle selection, a number of pushbuttons and/or proportional functions.

Handle / Top functions

To provide optimum user comfort, a selection of handles is available. Each handle offers a choice of push buttons and / or proportional functions positioned for ease of use and comfort.

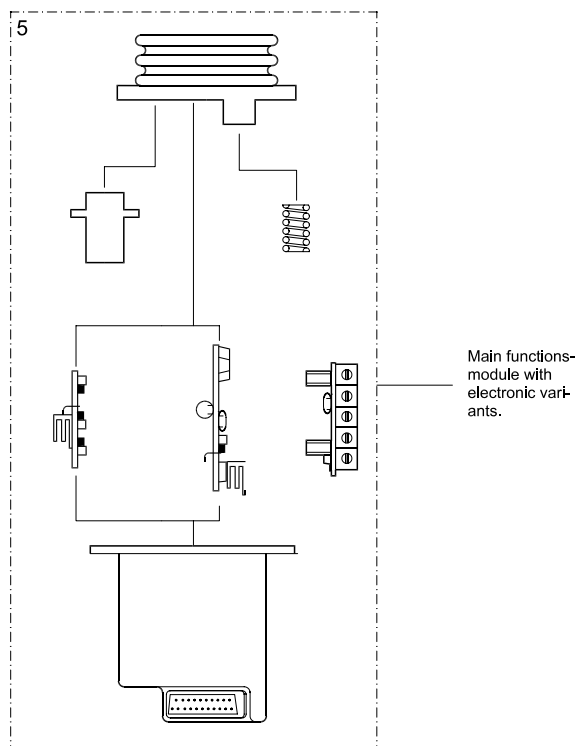


162B91.10.10

Prof Joysticks

Base module

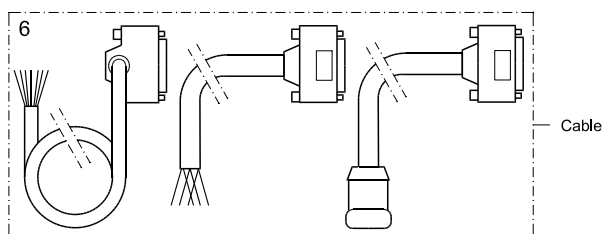
A number of electronic modules provide various performance levels to cater for different needs in different applications.



162B92.10

Cable

For easy integration into existing applications cables with different connectors are available as accessories, see page 5.



162B93.10

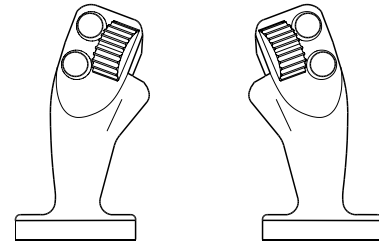
Prof 1

Prof 1

A professional handle for intensive operation; with a forward-leaning, curved, ergonomic shape. The leather-like grained surface allows the palm of the hand to breathe during operation.

The Prof 1 handle can be fitted with up to seven push buttons, or up to two proportional functions with up to five push buttons.

For location and combination of function modules see the overview.



LH

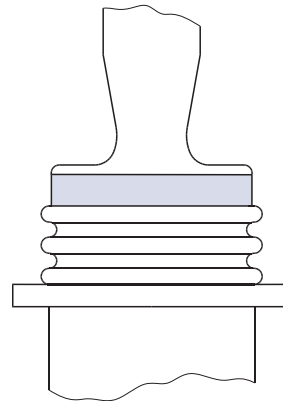
RH

162B94.10

Color Band

A choice of colors is available for the band at the base of the handle.

Colors
Yellow
Black
Red



162B08.10

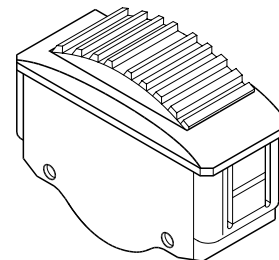
Proportional Modules

The roller function module is a spring centred potentiometer with integrated direction switches.

Working angle: $\pm 42^\circ$

Direction switch angle: $3.5 \pm 2^\circ$

Signal range	Neutral signal
25% – 75%	50%
of supply voltage	



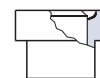
162B62.10

Push Buttons

The handle can be fitted with up to seven independent On/Off functions.

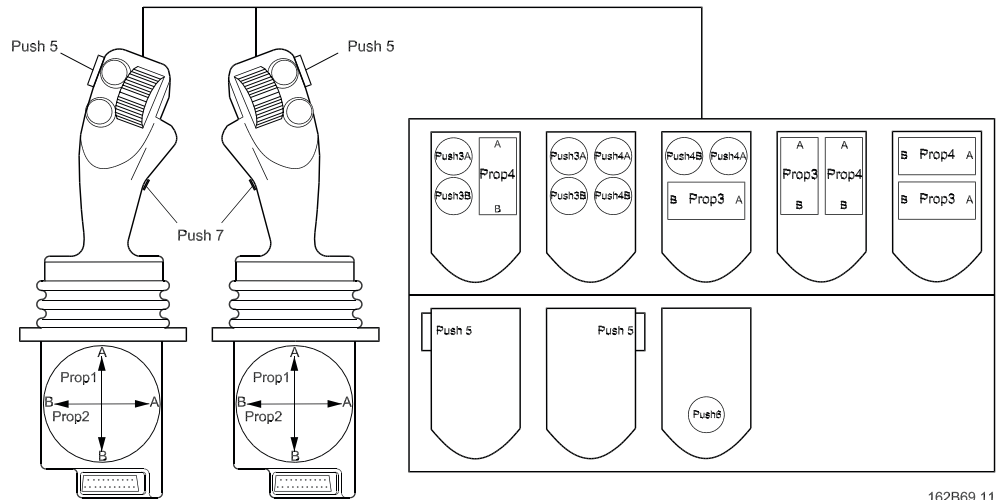
The buttons are protected against shocks and unintentional activation by a high collar.

Colors
Yellow
Black
Red
Grey



162B52.10

Location and Orientation of Modules



162B69.11

Electronic Modules

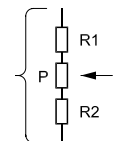
The electronic modules are available with four different performance levels: Basic, Standard, Extended, and CAN-enabled.

Basic

The Basic level module is a connection platform that contains no electronics. This version offers raw signals from function modules, proportional modules, and push buttons.

The Basic level module contains no kind of protection, amplification, neutral switches, relays, or filtering and meets no legal specifications.

The proportional functions in the basic module are configured like this:



162B72.10

The value of P is 5 K Ω , R1 and R2 are 1.125 K Ω (See technical data for tolerances).

This configuration ensures that the output signal will be at least 25%-75% of the supply voltage.

Note: Because of the output impedance of the sensors, it is recommended to use an amplifier if the application draws more than 15 μ A.

Electronic Modules

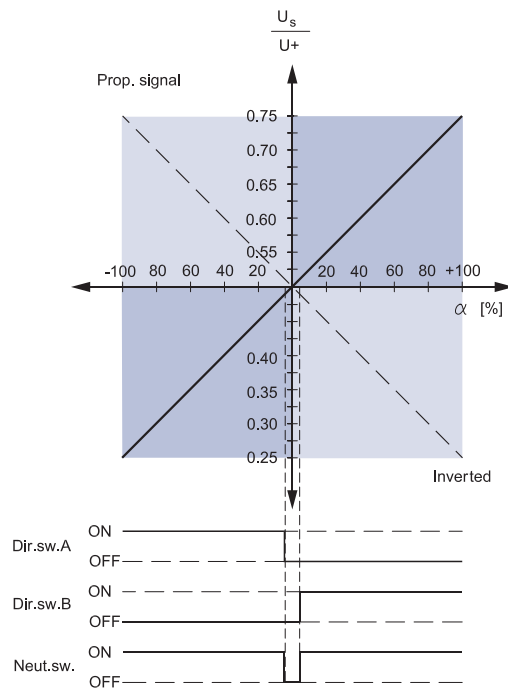
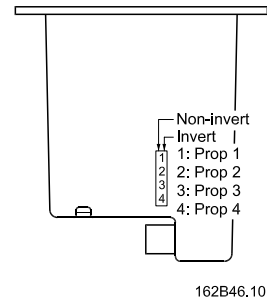
Standard

The Standard level electronic module provides amplifiers, inverting and signal relays on all proportional outputs, and an electronic switch on all On/Off outputs.

The signal relays are controlled by the power supply in such a way that a power failure will disconnect the output. (This will automatically send a Sauer-Danfoss proportional valve to neutral position)

When used together with a Sauer-Danfoss proportional valve signal inversion causes the joystick to move the spool in the direction opposite to the default. This is equivalent to swapping the hoses on the valve outlets.

Note: The directional switches are not affected by the signal inversion.

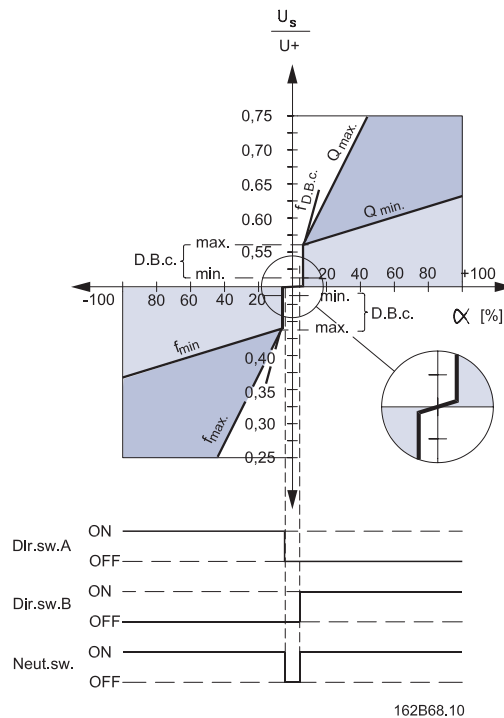


Factory setting: Non-inverted

Electronic Modules

Extended

The Extended level electronic module has the same configuration as the Standard level module. Additionally it has adjustable proportional functions. The Extended level module offers the option of individual signal adaptation (flow adjustment) and common dead-band compensation.



The dead band compensation (D.B.c.) ensures that the dead band of the valve is reduced to a minimum movement of the grip.

The dead band compensation is only active outside the neutral range, which ensures normal amplification within the neutral position range.

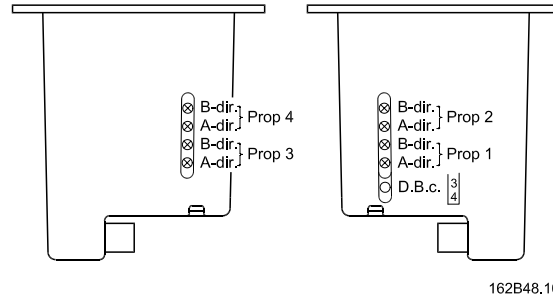
The dead band compensation is set for all four proportional functions on one potentiometer.

For each proportional function there are two integrated potentiometers that independently control the gain for the A and B directions of the signal output without limiting the movement range of the handle (adjustable flow range).

The gain of each function can be adjusted from 0.25 to 2.00. This has no effect within the D.B.c. range.

Electronic Modules

Location of potentiometers for adjusting D.B.c and gain:

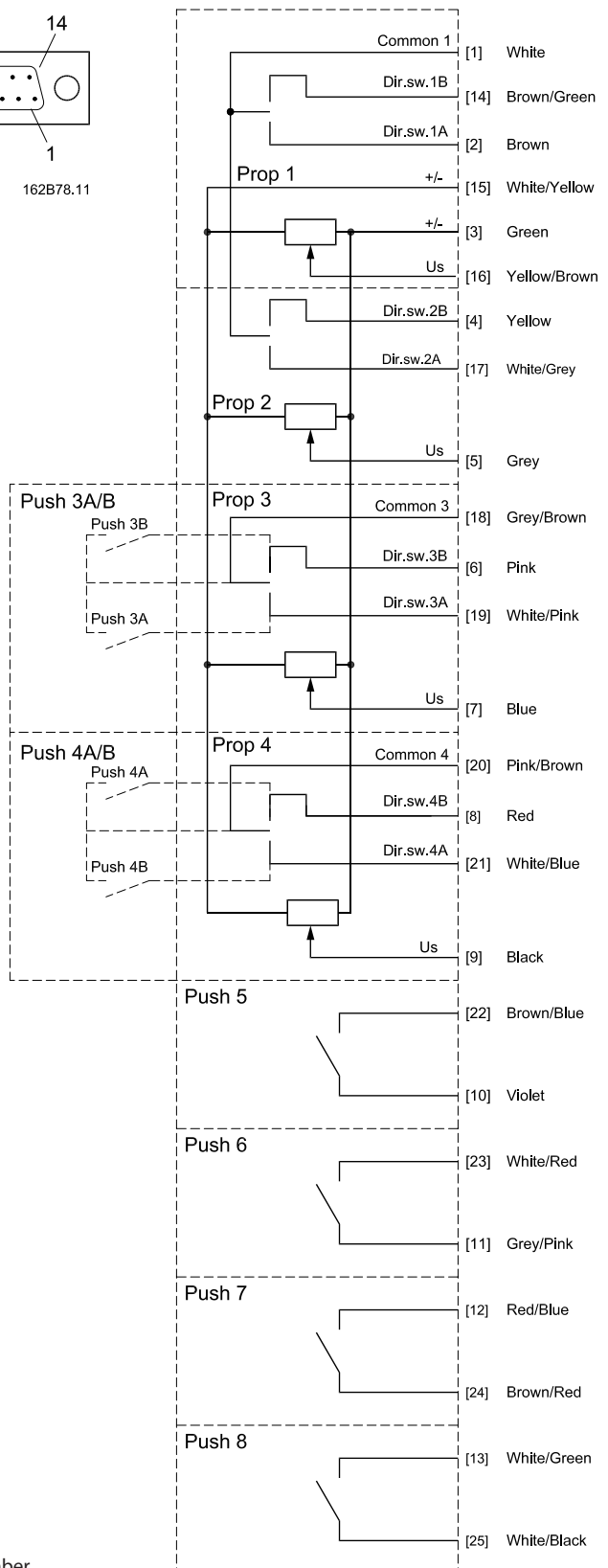
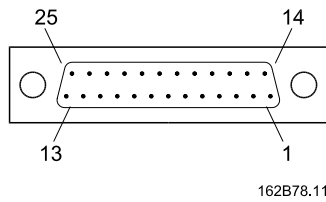


Factory setting @ 12 V	
Dead band compensation	0.42 V
Signal gain	0.86

CAN-enabled

There is a CAN-enabled electronic module available for the Prof family of joysticks. The module provides a standard CANOpen interface. For further information read Sauer-Danfoss Technote on CAN bus components and see our webpage: <http://www.sauer-danfoss.com>

Connections – Basic

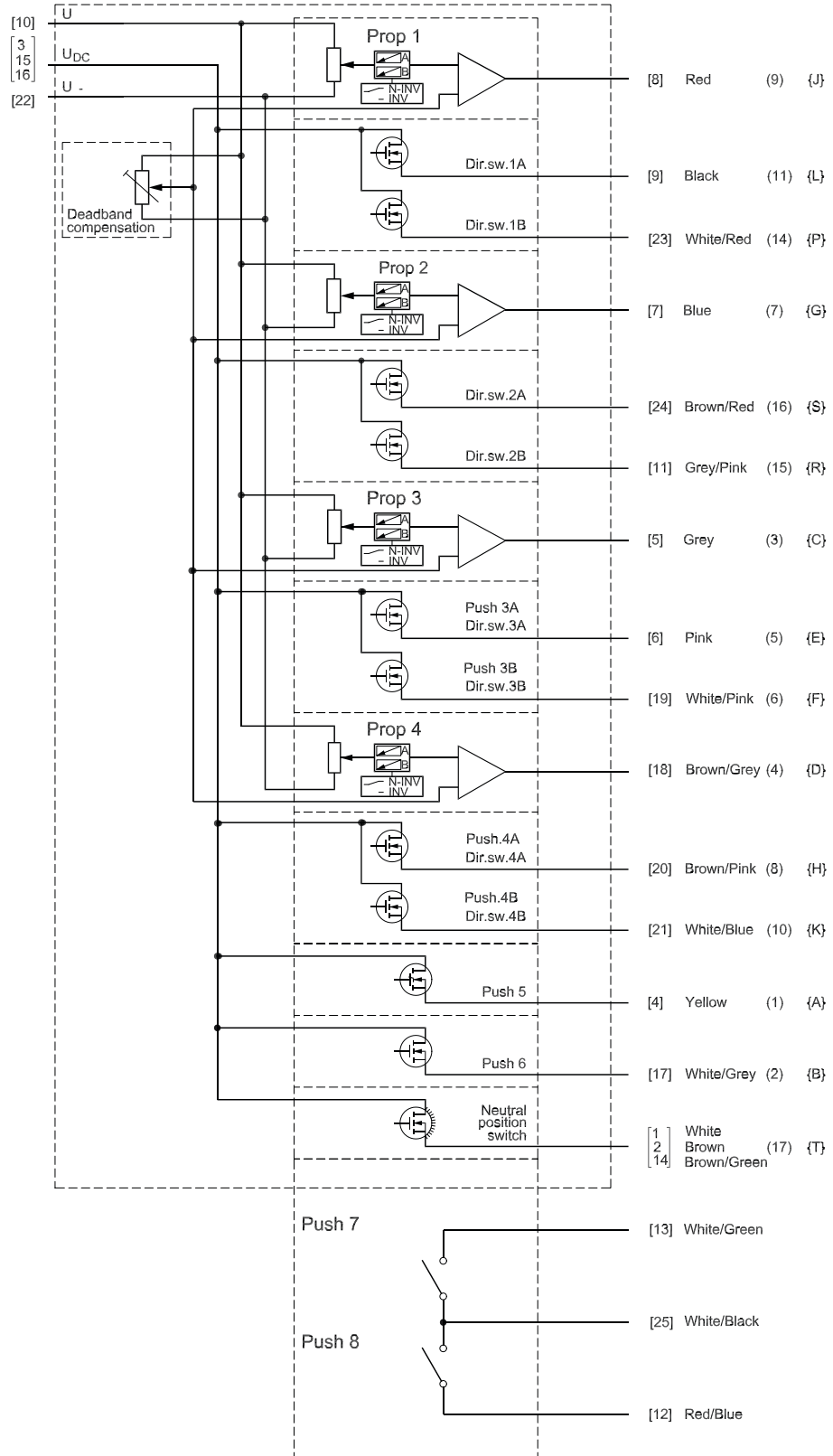
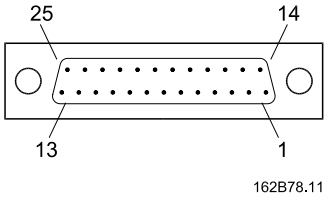


Numbers in [] indicate pin number
in sub-D connector.

162B61.11

Connections
- Standard
- Extended

{N}	(13) Violet Green
{U}	(18) White/Yellow Brown/Yellow
{M}	(12) Brown/Blue



Numbers in [] indicate pin number
in sub-D connector.

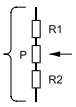
162B59.12

Technical Data

All

Enclosure	Below flange	IP 21
	Above flange	IP 50
Ambient temperature		-30 - +60° [-22 - +140°F]
Max. force on handle		1000 N static

Basic

Supply voltages	U ₊	≤30 V
Proportional functions		5 kΩ ±50%
	R1 & R2	P × 0.225 ±1%
Max signal current		15 μA (1 mA peak)
Max direction switch load for all proportional functions		30 V _{DC} / 2mA
Max push button load		30 V _{DC} / 50mA

Note: There are no electronics built in to the Basic level module.

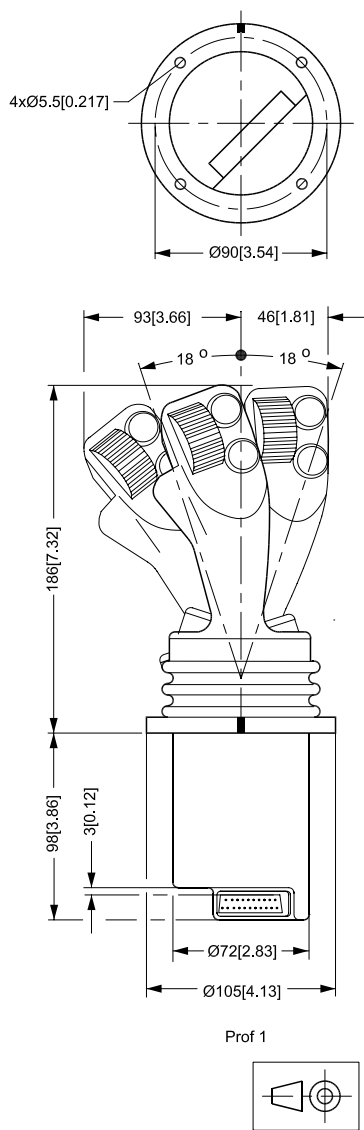
Standard and Extended

Supply voltages	U _{DC} , U ₊	10-30 V
	Max ripple	5%
Current consumption		≈150 mA
Signal voltage U _s	U _s Min → Max	0.25 → 0.75
	U ₊ Neutral position	0.50
Signal load in neutral position	Load type	PVE Other
	Load impedance	>6 kΩ >15 kΩ
Signal current at max movement	@ U _{DC} = 12 V	U _s - 0.5 × U ₊ U _s 6 kΩ 15 kΩ ± 0.6 mA 0.2 → 0.6 mA
	@ U _{DC} = 24 V	± 1.2 mA 0.4 → 1.2 mA
Signal current in neutral position	@ U _{DC} = 12 V	± 0 mA 0.4 mA
	@ U _{DC} = 24 V	± 0 mA 0.8 mA
Inverter	Non inverted	Output signal = U _s
	Inverted	Output signal = -1 × (U _s - 0.5 × U ₊) + 0.5 × U ₊
Push buttons and directions switches for all proportional functions	Max load	0.6 A
Push 7 & Push 8	Max load	30 V _{DC} / 50 mA
Neutral position switch	Max load	3 A

Extended only

Signal regulation U _s	U _s Min (50%)	0.37 → 0.63 at 100% movement
	U ₊ Max (200%)	0.25 → 0.75 at 50% movement
Dead band compensation	U _s Min	0.00
	U ₊ Max	0.06

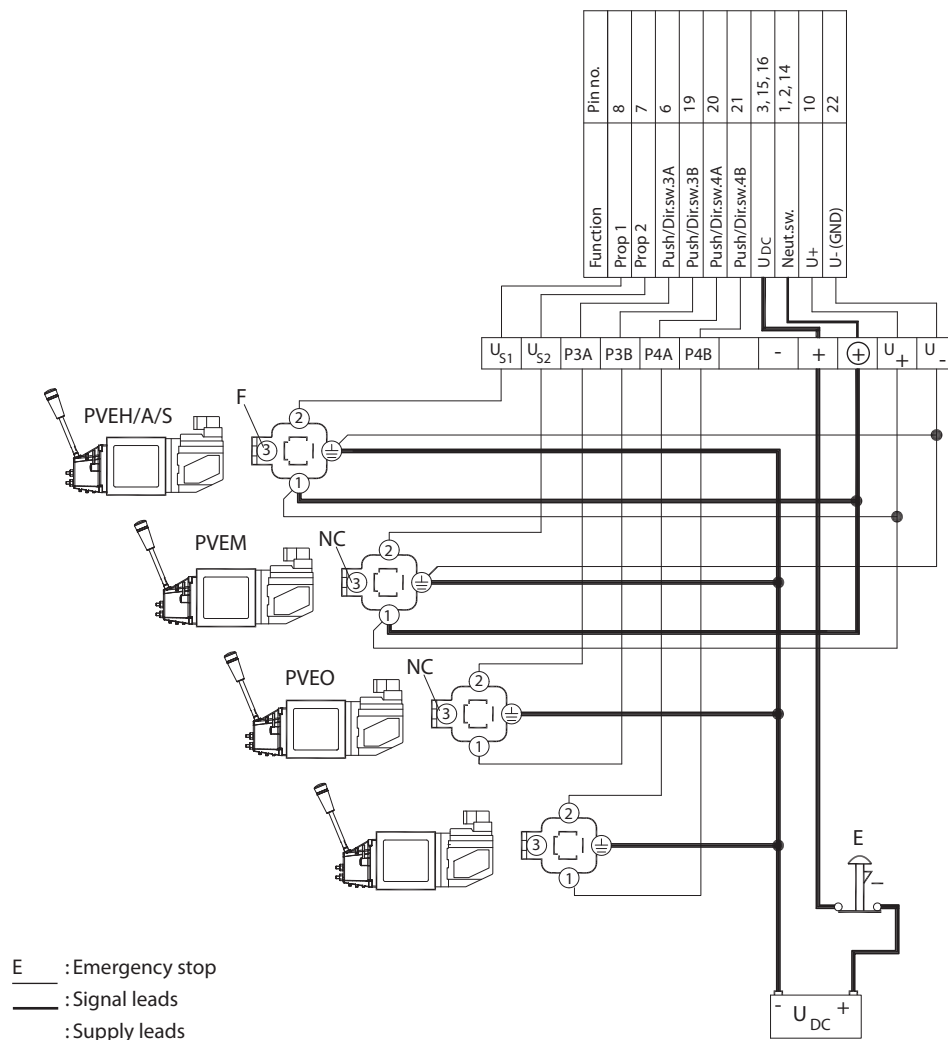
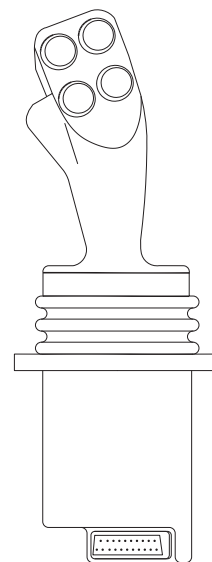
Dimensions



162B129.10

Examples of Use

Signal leads must not also function as supply leads unless the distance between PVE and terminal board is less than 3 m [120 in] and the lead cross-section is $\geq 0.75 \text{ mm}^2$ [AWG 18].

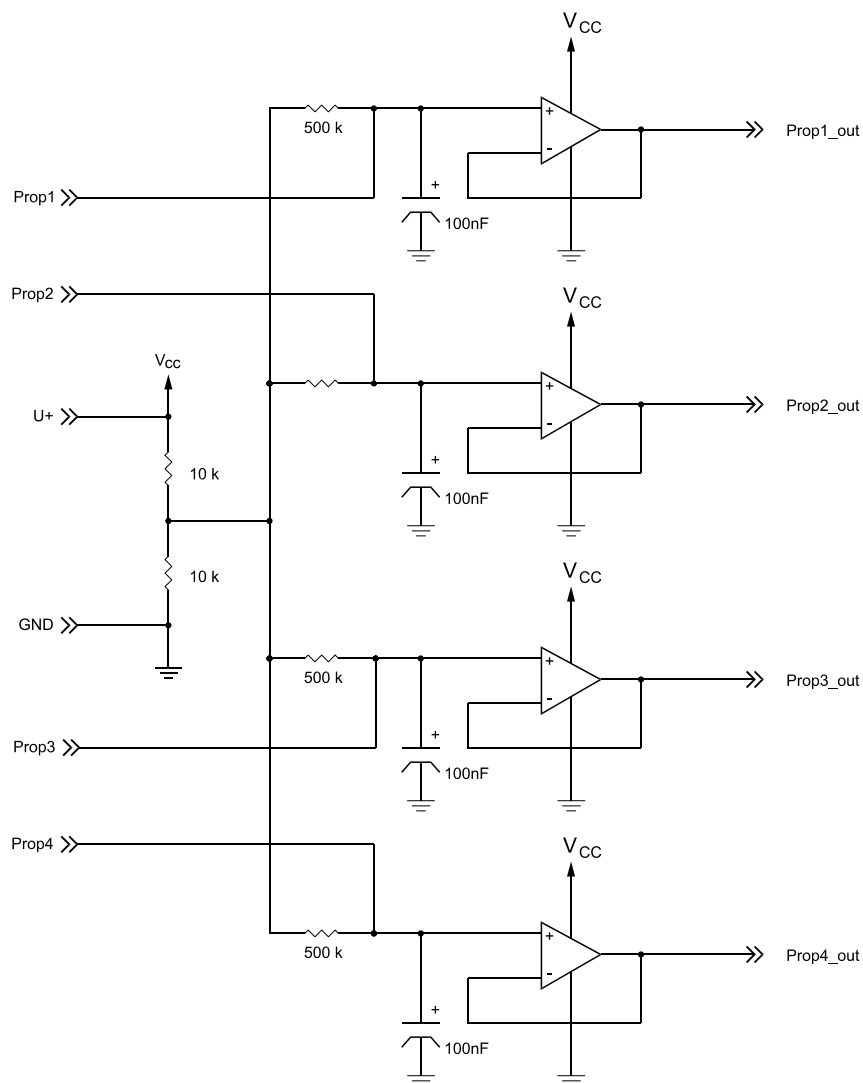


V310116.A

Examples of Use

Basic version used with controller

When using the Basic level module with a controller, it is recommended to use a filter similar to the one in the figure below to ensure a symmetric and limited load on the proportional sensors.



162B97.10

Note: There are no electronics built in to the Basic level module

Prilog 9: Rotacioni senzor RM 36

RM36 series non-contact rotary encoders



The RM36 is a high-speed magnetic rotary encoder designed for use in harsh industrial environments. The non-contact two-part design removes the need for seals or bearings ensuring long-term reliability and simple installation.

The encoder comprises a magnetic actuator and a separate encoder body. Rotation of the magnetic actuator is sensed by a custom encoder chip within the body, and processed to the required output.

The encoder chip processes the signals received to provide resolutions to 13 bit (8,192 positions per revolution) with high operational speeds. Resolution options include binary and decimal. Output signals are provided in industry standard absolute, incremental or linear formats.

The compact encoder body is 36 mm in diameter and provides dirt immunity up to IP68.

The RM36 can be used in a wide range of applications including marine, medical, print, converting, industrial automation, metal working, motor control and instrumentation.

5 V power supply version

RM36I-incremental with 80 to 2,048 pulses per revolution (320 to 8,192 counts per revolution with x 4 evaluation)

RM36S-synchro serial interface (SSI) with 320 to 8,192 positions per revolution

24 V power supply version

RM36P-absolute parallel interface with 512 positions per revolution

RM36I-incremental with 80 to 2,048 pulses per revolution (320 to 8,192 counts per revolution with x 4 evaluation)

RM36V-linear voltage output in a range of variants

RM36C-linear current output in a range of variants

System features:

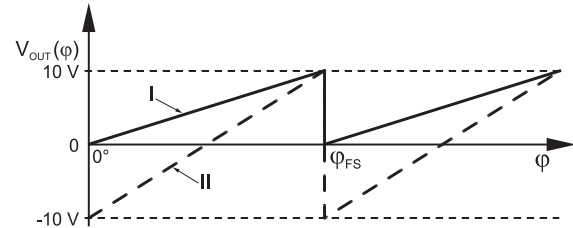
- **Excellent immunity to IP68**
- **Non-contact, frictionless design**
- **High speed operation to 30,000 rpm**
- **36 mm diameter body**
- **Industry standard absolute, incremental and linear output formats**
- **Binary and decimal resolution options**
- **Accuracy $\pm 0.5^\circ$**
- **Simple installation**
- **Low inertia**
- **Stainless steel body option**

Output specifications - 24 V supply

RM36V – Linear voltage output

Power supply	Type I: +20 V to +30 V DC Type II: ± 12 V to ± 16 V DC
Power consumption	40 mA typical
Output voltage	Type I: 0 V to 10 V DC Type II: -10 V to +10 V DC
Output loading	Max. 10 mA
Nonlinearity	1 %
Max. cable length	20 m
Connector options	9 pin 'D' type plug (standard) Flying lead
Temperature	Operating -25 °C to +70 °C Storage -25 °C to +125 °C
Maximum speed	30,000 rpm

Electrical output/shaft position



Output type and electrical variant

	Type I				Type II			
ϕ_{FS}	360°	180°	90°	45°	360°	180°	90°	45°
CW	VA	VB	VC	VD	VM	VN	VP	VQ
CCW	VE	VF	VG	VH	VR	VS	VT	VV

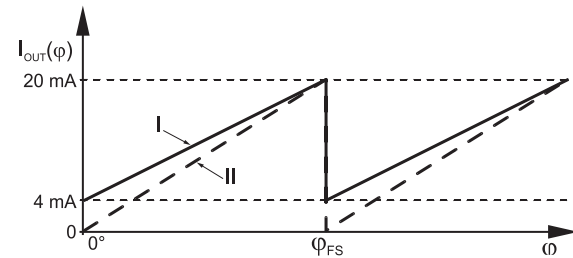


Image shows clockwise rotation of magnetic actuator

RM36C - Linear current output

Power supply	$V_{dd} = +20$ V to +30 V DC
Power consumption	50 mA plus output current
Output current	Type I: 4 mA to 20 mA Type II: 0 mA to 20 mA
Output loading	$R_L = 0$ to $\frac{V_{dd}}{I_{OUTmax}}$
Nonlinearity	1 %
Max. cable length	20 m
Connector options	9 pin 'D' type plug (standard) Flying lead
Temperature	Operating -25 °C to +70 °C Storage -25 °C to +125 °C
Maximum speed	30,000 rpm

Electrical output/shaft position



Output type and electrical variant

	Type I				Type II			
ϕ_{FS}	360°	180°	90°	45°	360°	180°	90°	45°
CW	CA	CB	CC	CD	CM	CN	CP	CQ
CCW	CE	CF	CG	CH	CR	CS	CT	CV



Image shows clockwise rotation of magnetic actuator

Prilog 10: Senzor linearnog pomaka MK 77



More Precision

wireSENSOR

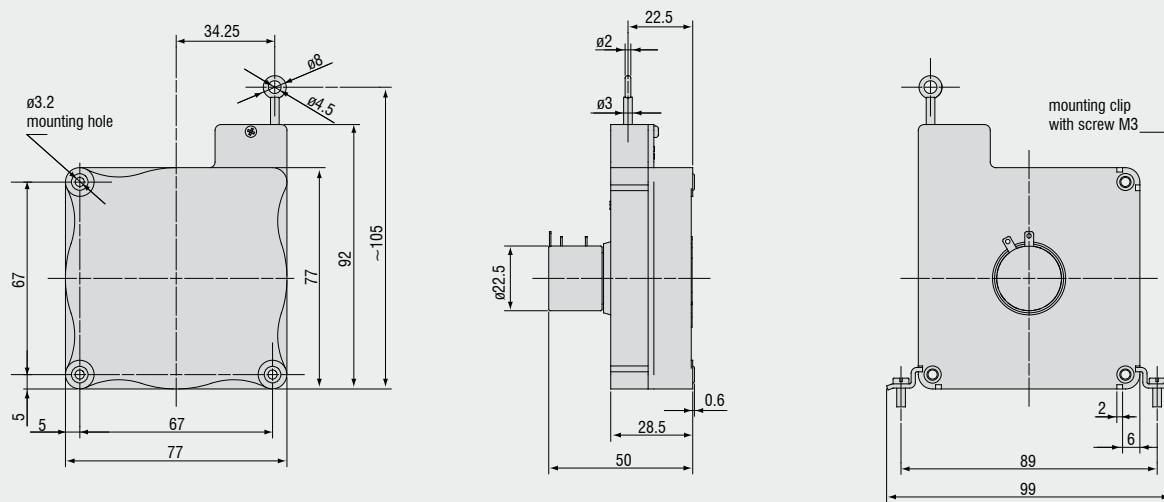
Draw-wire displacement sensors



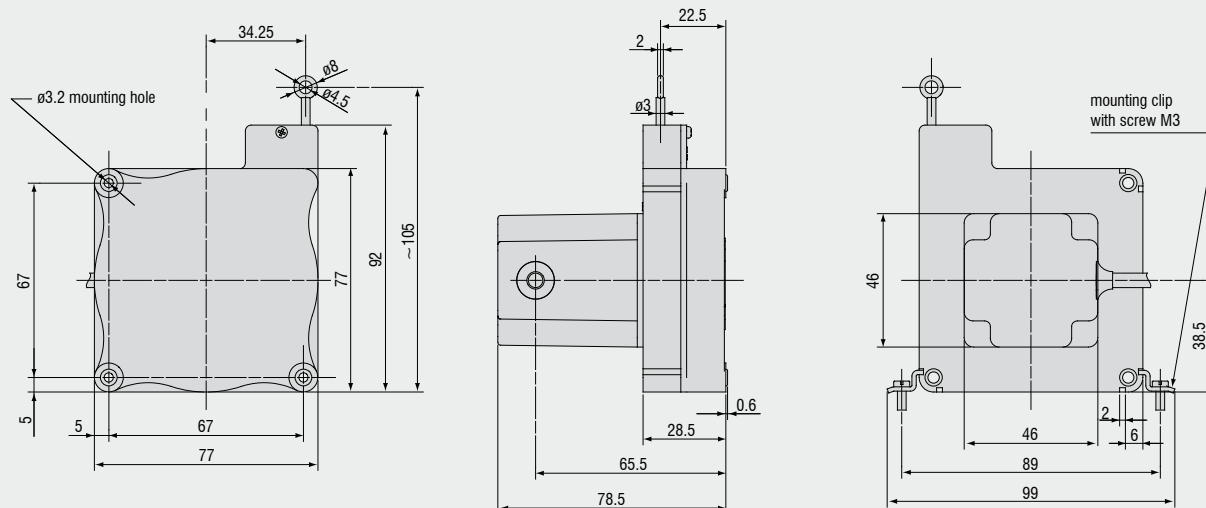


- Robust plastic housing
- Customized versions for OEM
- Wire potentiometer

Model MK77 Output P25



Model MK77 Output CR-P25



Model		WPS-2100-MK77	
Output		P25	
Measuring range		2100mm	
Linearity	wire pot.	<0.25% FSO	5.25mm
Resolution	wire pot.		0.55mm
Sensor element		wire potentiometer	
Temperature range		-20 to 80°C	
Material	housing	plastic	
	draw wire	coated polyamid stainless steel	
Wire mounting		eyelet	
Sensor mounting		mounting holes / mounting grooves	
Cable diameter		0.45mm	
Wire retraction force (min)		3.5N	
Wire extension force (max)		5N	
Wire acceleration		5g	
Protection class		IP 20	
Electrical connection	P25	soldering tag	
	CR-P25	integrated cable radial, 1m	
Weight	P25	ca. 0.2kg	
	CR-P25	ca. 0.25kg	

FSO = Full Scale Output
Specifications for analog outputs on page 47.

Article description

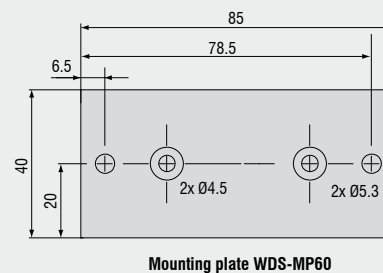
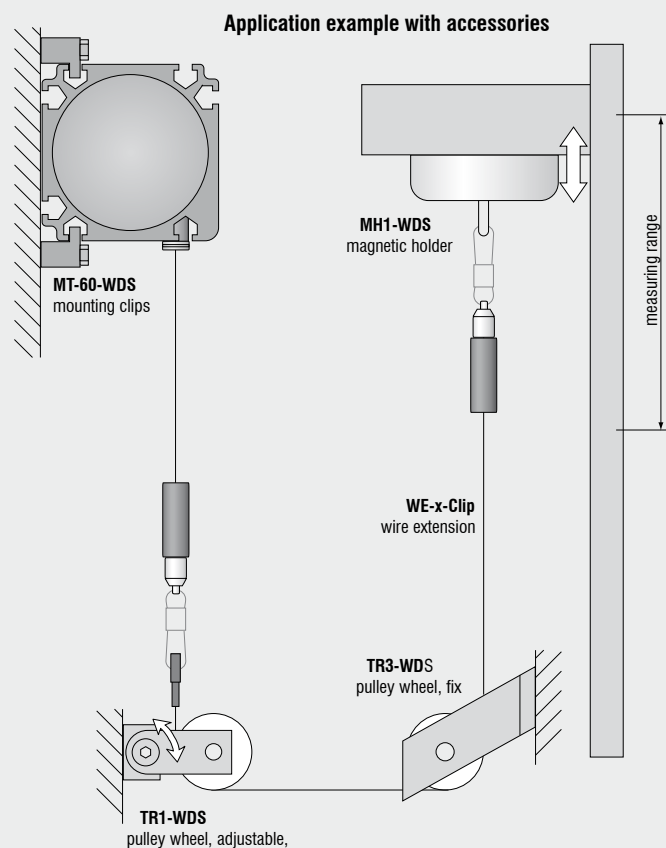
WPS - 2100 - MK77 - P25

Output option:
potentiometer P25 (linearity <0.25% FSO)
potentiometer CR-P25, integrated cable, radial, 1m

Model MK77

Measuring range in mm

WE-x-M4, WE-x-Clip	Wire extension x=length
TR1-WDS	Pulley wheel, adjustable
TR3-WDS	Pulley wheel, fixed
GK1-WDS	Attachment head for M4
MH1-WDS	Magnetic holder for wire mounting
MH2-WDS	Magnetic holder for sensor mounting
MT-60-WDS	Mounting clamp for WDS-P60
FC8	Female connector for WDS, 8-pin
FC8/90	Female connector 90° for WDS
PC 3/8	Sensor cable, lenght 3 m
PS 2010	Power supply (chassis mounting 35 x 7.5 mm); input 120/230 VAC; output 24 VDC/2.5 A; L/B/H 120 x 20 x 40 mm
WDS-MP60	Mounting plate for P60 sensors

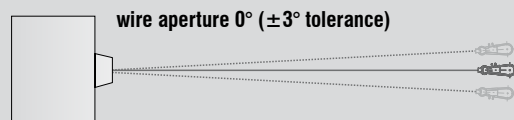


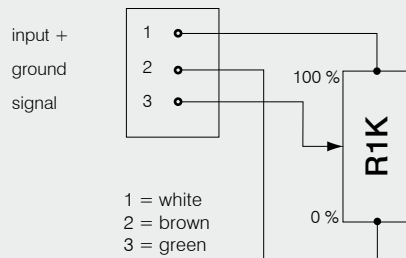
Installation information:

Wire attachment: The free return of the measurement wire is not permissible and it is essential that this is avoided during installation.

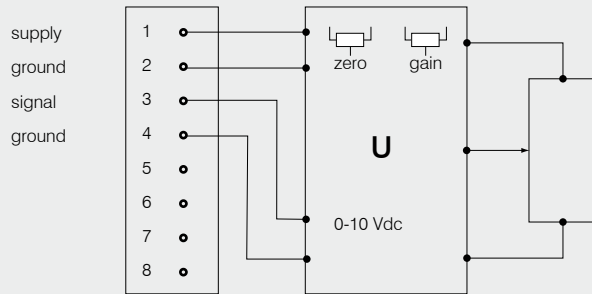
Wire exit angle:

When mounting a draw-wire displacement sensor, a straight wire exit ($\pm 3^\circ$ tolerance) must be taken into account. If this tolerance is exceeded, increased material wear on the wire and at the wire aperture must be expected.

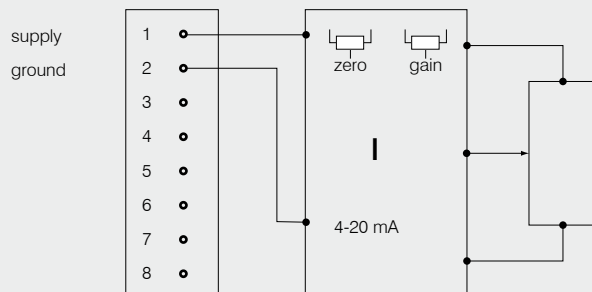




Potentiometric output (P)	
Supply voltage	max. 32VDC at 1kOhm / 1 Wmax
Resistance	1kOhm $\pm 10\%$ (potentiometer)
Temperature coefficient	$\pm 0.0025\%$ FSO/ $^{\circ}\text{C}$
Sensitivity	depends on measuring range individually shown on test report



Voltage output (U)	
Supply voltage	14 ... 27VDC (non stabilized)
Current consumption	30mA max
Output voltage	0 ... 10VDC Option 0 ... 5 / $\pm 5\text{V}$
Load impedance	$> 5\text{kOhm}$
Signal noise	$0.5\text{mV}_{\text{eff}}$
Temperature coefficient	$\pm 0.005\%$ FSO/ $^{\circ}\text{C}$
Electromagnetic compatibility (EMC)	EN 50081-2 EN 50082-2
Adjustment ranges	
Zero	$\pm 20\%$ FSO
Sensitivity	$\pm 20\%$



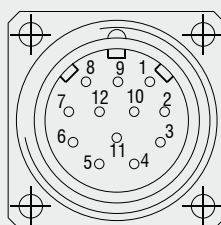
Current Output (I)	
Supply voltage	14 ... 27VDC (non stabilized)
Current consumption	35mA max
Output current	4 ... 20mA
Load	$< 600\text{Ohm}$
Signal noise	$< 1.6\mu\text{A}_{\text{eff}}$
Temperature coefficient	$\pm 0.01\%$ FSO/ $^{\circ}\text{C}$
Electromagnetic compatibility (EMC)	EN 50081-2 EN 50082-2
Adjustment ranges	
Zero	$\pm 18\%$ FSO
Sensitivity	$\pm 15\%$

Contact description

1 UB	Encoder power supply connection.
2 GND	Encoder ground connection. The voltage drawn to GND is UB.
3 Pulses +	Positive SSI pulse input. Pulse + forms a current loop with pulse -. A current of approx. 7 mA in direction of pulse + input generates a logical 1 in positive logic.
4 Data +	Positive, serial data output of the differential line driver. A High level at the output corresponds to logical 1 in positive logic.
5 ZERO	Zero setting input for setting a zero point at any desired point within the entire resolution. The zeroing process is triggered by a High pulse (pulse duration ≥ 100 ms) and must take place after the rotating direction selection (UP/DOWN). For maximum interference immunity, the input must be connected to GND after zeroing.
6 Data -	Negative, serial data output of the differential line driver. A High level at the output corresponds to logical 0 in positive logic.
7 Pulses -	Negative SSI pulse input. Pulse - forms a current loop with pulse +. A current of approx. 7 mA in direction of pulse - input generates a logical 0 in positive logic.
8 / 10 $\overline{\text{DATAVALID}}$ $\overline{\text{DATAVALID MT}}$	Diagnosis outputs $\overline{\text{DV}}$ and $\overline{\text{DV MT}}$ Jumps in data word, e.g. due to defective LED or photoreceiver, are displayed via the $\overline{\text{DV}}$ output. In addition, the power supply of the multiturn sensor unit is monitored and the $\overline{\text{DV MT}}$ output is set when a specified voltage level is dropped below. Both outputs are Low-active, i.e. are switched through to GND in the case of an error.
9 UP/DOWN	UP/DOWN counting direction input. When not connected, this input is on High. UP/ DOWN-High means increasing output data with a clockwise shaft rotating direction when looking at the flange. UP/ DOWN-Low means increasing values with a counter-clockwise shaft rotating direction when looking at the flange.
11 / 12	Not in use

Pin assignment

Pin	Cable color	Assignment
1	brown	UB
2	black	GND
3	blue	Pulses +
4	beige	Data +
5	green	ZERO
6	yellow	Data -
7	violet	Pulses -
8	brown/yellow	$\overline{\text{DATAVALID}}$
9	pink	UP/ DOWN
10	black/yellow	$\overline{\text{DATAVALID MT}}$
11	-	-
12	-	-



Please use leads twisted in pairs for extension cables.

Inputs

Control signals UP/DOWN and Zero

Level High > 0.7UB

Level Low < 0.3UB

Connection: UP/DOWN input with 10kohms to UB, zeroing input with 10kohms to GND.

SSI pulse

Optocoupler inputs for electrical isolation

Outputs

SSI data RS485 driver

Diagnostic outputs

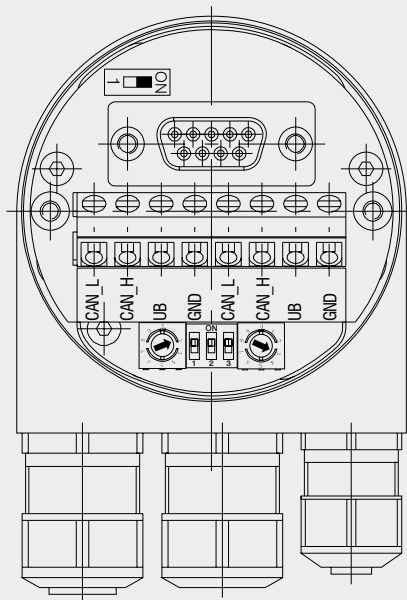
Push-pull outputs are short-circuit-proof

Level High > UB -3.5V (with I = -20mA)

Level Low $\leq 0.5V$ (with I = 20mA)

CANopen features

Bus protocol	CANopen
Device profile	CANopen - CiA DSP 406, V 3.0
CANopen Features	Device Class 2, CAN 2.0B
Operating modes (with SDO progr.)	<p>Polling Mode (asynch, via SDO)</p> <p>Cyclic Mode (asynch-cyclic) The encoder cyclically sends the current process actual value without a request by a master. The cycle time can be parameterized for values between 1 and 65535 ms. Synch Mode (synch-cyclic) The encoder sends the current actual process value after receiving a synch telegram sent by a master. The synch counter in the encoder can be parameterized so that the position value is not sent until after a defined number of synch telegrams.</p> <p>Acyclic Mode (synch-acyclic)</p>
Preset value	With the "Preset" parameter the encoder can be set to a desired actual process value that corresponds to the defined axis position of the system. The offset value between the encoder zero point and the mechanical zero point of the system is saved in the encoder.
Rotating direction	<p>With the operating parameter the rotating direction in which the output code is to increase or decrease can be parameterized.</p> <p>Scaling The steps per revolution and the total revolution can be parameterized.</p>
Scaling:	The steps per revolution and the total revolution can be parameterized.
Diagnose	<p>The encoder supports the following error messages:</p> <ul style="list-style-type: none"> - Position and parameter error - Lithium cell voltage at lower limit (Multiturn)
Default setting	50kbit/s, node number 1



Setting of terminating Resistor for CANopen



ON = Last user
OFF = User X

Setting CANopen baud rate

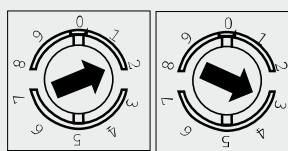
Baud rate	Setting Dip Switch		
	1	2	3
10kBit/s	OFF	OFF	OFF
20kBit/s	OFF	OFF	ON
50kBit/s	OFF	ON	OFF
125kBit/s	OFF	ON	ON
250kBit/s	ON	OFF	OFF
500kBit/s	ON	OFF	ON
800kBit/s	ON	ON	OFF
1MBit/s	ON	ON	ON

Contact description CANopen

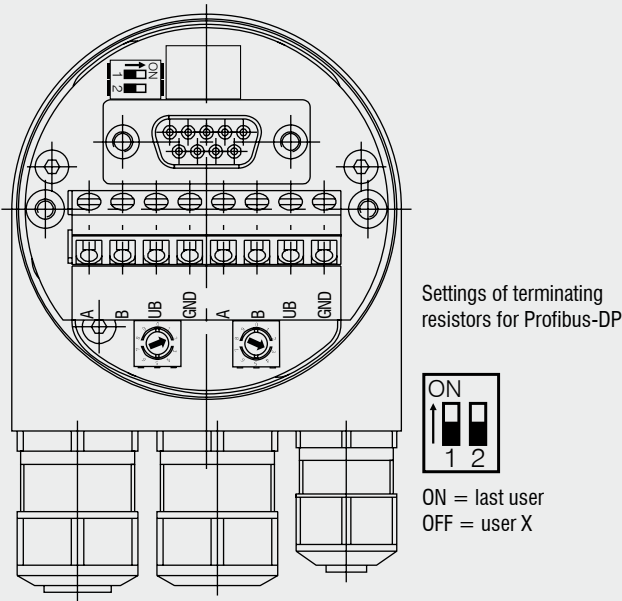
CAN_L	CAN Bus Signal (dominant Low)
CAN_H	CAN Bus Signal (dominant High)
UB	Versorgungsspannung 10...30VDC
GND	Ground contact for UB
(Terminals with the same designation are internally interconnected)	

Settings of user address for CANopen

Address can be set with rotary switch. Example: User address 23

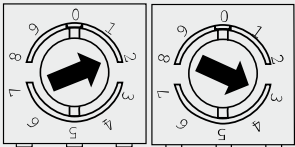


Profibus-DP features		
Bus protocol	Profibus-DP	
Profibus features	Device Class 1 and 2	
Data exch. functions	Input: Position value Additional parameterized speed signal (readout of the current rotary speed) Output: Preset value	
Preset value	With the "Preset" parameter the encoder can be set to a desired actual value that corresponds to the defined axis position of the system.	
Parameter functions	Rotating direction: With the operating parameter the rotating direction for which the output code is to increase or decrease can be parameterized.	
Diagnose	The encoder supports the following error messages: - Position error - Lithium cell voltage at lower limit (Multiturn)	
Default setting	User address 00	



Settings of user address for Profibus-DP

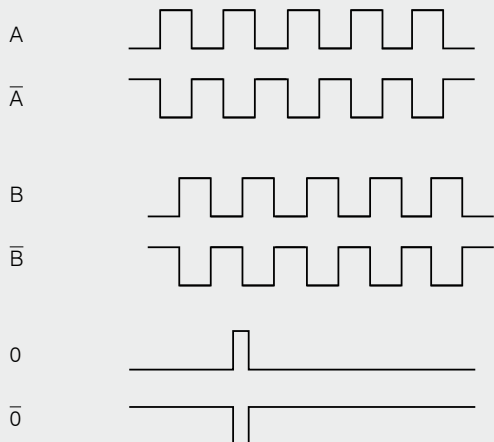
Address can be set with rotary switch. Example: User address 23



Contact description Profibus-DP
A A negative serial data line
B Positive serial data line
UB Supply voltage 10...30VDC
GND Ground contact for UB

(Terminals with the same designation are internally interconnected)

Signal output



Output TTL

Linedriver (5VDC)

Level High	$\geq 2.5V$	(with $I = -20mA$)
Level Low	$\leq 0.5V$	(with $I = 20mA$)
Load High	$\leq 20mA$	
Output	A, \bar{A} , B, \bar{B} , 0	

Output HTL

Push-pull (10 ... 30VDC)

Level High	$\geq UB - 3V$	(with $I = -20mA$)
Level Low	$\leq 1.5V$	(with $I = 20mA$)
Load High	$\leq 40mA$	
Output	A, \bar{A} , B, \bar{B} , 0	

Output E

Push-pull (5VDC)

Level High	$UB - 2.5V$
Level Low	$\leq 0.5V$
Load High	$\leq 50mA$
Output	A, B, 0

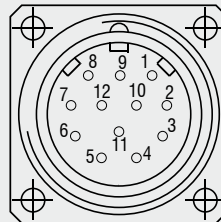
Output E830

Push-pull (8 ... 30VDC)

Level High	$UB - 3V$
Level Low	$\leq 2.5V$
Load High	$\leq 50mA$
Output	A, B, 0

Pin assignment TTL, HTL

Pin	Cable color	Assignment
1	pink	B inv.
2	blue	UB Sense
3	red	N (Nullimpulses)
4	black	N inv. (Nullimpulses inv.)
5	brown	A
6	green	A inv.
7	-	-
8	grey	B
9	-	-
10	white/green	GND
11	white	GND Sense
12	brown/green	UB



Pin 2 and Pin 12 are internally connected as well as Pin 11 and 10.
For cable length >10m twisted pair wires are required.

Connection assignment E, E830

Pin	Cable color	Assignment
-	white	0V
-	brown	+UB
-	green	A
-	-	\bar{A}
-	yellow	B
-	-	\bar{B}
-	grey	0

Prilog 11: Senzor sile U9C

Pressure Measurement

Transmitters for basic requirements

SITRANS P220 for gauge pressure

Overview



The pressure transmitter SITRANS P220 measures the gauge pressure of liquids, gases and vapors.

- Stainless steel measuring cell, fully welded
- Measuring ranges 2.5 to 600 bar (36.3 to 8702 psi) relative
- For high-pressure applications and refrigeration technology division

Benefits

- High measuring accuracy
- Rugged stainless steel enclosure
- High overload withstand capability
- For aggressive and non-aggressive media
- For measuring the pressure of liquids, gases and vapors
- Compact design
- Gasket-less

Application

The pressure transmitter SITRANS P220 for gauge pressure is used in the following industrial areas:

- Mechanical engineering
- Shipbuilding
- Power engineering
- Chemical industry
- Water supply

Design

Device structure without explosion protection

The pressure transmitter consists of a piezoresistive measuring cell with a diaphragm installed in a stainless steel enclosure. It can be used with a connector per EN 175301-803-A (IP65), a round plug M12 (IP67), a cable (IP67) or a Quickon cable quick screw connection (IP67) connected electrically. The output signal is between 4 and 20 mA or 0 and 10 V.

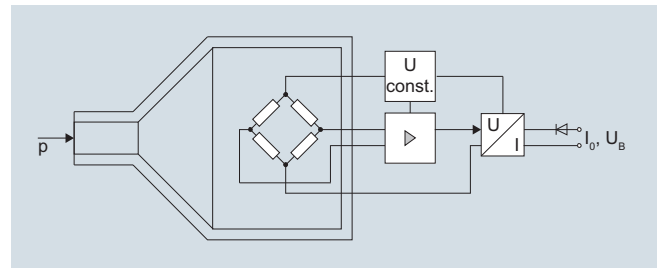
Device structure with explosion protection

The pressure transmitter consists of a piezoresistive measuring cell with a diaphragm installed in a stainless steel enclosure. It can be used with a connector per EN 175301-803-A (IP65) or a round plug M12 (IP67) connected electrically. The output signal is between 4 and 20 mA.

Function

The pressure transmitter measures the gauge pressure of liquids and gases as well as the level of liquids.

Mode of operation



SITRANS P220 pressure transmitters (7MF1567-...), functional diagram

The stainless steel measuring cell has a thick-film resistance bridge to which the operating pressure p is transmitted through a stainless steel diaphragm.

The voltage output from the measuring cell is converted by an amplifier into an output current of 4 to 20 mA or an output voltage of 0 to 10 V DC.

The output current and voltage are linearly proportional to the input pressure.

Pressure Measurement

Transmitters for basic requirements

SITRANS P220 for gauge pressure

1

Technical specifications

Application	
Gauge pressure measurement	Liquids, gases and vapors
Mode of operation	
Measuring principle	Piezoresistive measuring cell (stainless steel diaphragm)
Measured variable	Gauge pressure
Inputs	
Measuring range	
• Gauge pressure	
- Metric	2.5 ... 600 bar (36 ... 8700 psi)
- US measuring range	30... 8700 psi
Output	
Current signal	4 ... 20 mA
• Load	($U_B - 10\text{ V}$)/0.02 A
• Auxiliary power U_B	DC 7 ... 33 V (10 ... 30 V for Ex)
Voltage signal	0 ... 10 V DC
• Load	$\geq 10\text{ k}\Omega$
• Auxiliary power U_B	12 ... 33 V DC
• Power consumption	< 7 mA at 10 k Ω
Characteristic curve	Linear rising
Measuring accuracy	
Error in measurement at limit setting incl. hysteresis and reproducibility	<ul style="list-style-type: none"> • Typical: 0.25 % of full-scale value • Maximum: 0.5 % of full-scale value
Step response time T_{99}	< 5 ms
Long-term stability	
• Lower range value and measuring span	0.25 % of full-scale value/year
Influence of ambient temperature	
• Lower range value and measuring span	0.25 %/10 K of full-scale value
• Influence of power supply	0.005 %/V
Conditions of use	
• Process temperature	-30 ... +120 °C (-22 ... +248 °F)
• Ambient temperature	-25 ... +85 °C (-13 ... +185 °F)
• Storage temperature	-50 ... +100 °C (-58 ... +212 °F)
• Degree of protection (to EN 60529)	<ul style="list-style-type: none"> • IP 65 with connector per EN 175301-803-A • IP 67 with M12 connector • IP 67 with cable • IP 67 with cable quick screw connection
Electromagnetic compatibility	<ul style="list-style-type: none"> • acc. IEC 61326-1/-2/-3 • acc. NAMUR NE21, only for ATEX versions and with a max. measuring deviation $\leq 1\%$

Design

Weight	Approx. 0.090 kg (0.198 lb)
Process connections	See dimension drawings
Electrical connections	<ul style="list-style-type: none"> • Connector per EN 175301-803-A Form A with cable inlet M16x1.5 or 1/2-14 NPT or Pg 11 • M12 connector • 2 or 3-wire (0.5 mm²) cable ($\varnothing \pm 5.4\text{ mm}$) • Quickon cable quick screw connection
Wetted parts materials	
• Measuring cell	Stainless steel, mat.-No. 1.4016
• Process connection	Stainless steel, mat. No. 1.4404 (SST 316 L)
Non-wetted parts materials	
• Enclosure	Stainless steel, mat. No. 1.4404 (SST 316 L)
• Rack	Plastic
• cables	PVC
Certificates and approvals	
Classification according to pressure equipment directive (PED 97/23/EC)	For gases of fluid group 1 and liquids of fluid group 1; complies with requirements of article 3, paragraph 3 (sound engineering practice)
Lloyd's Register of Shipping (LR)	12/20010
Germanischer Lloyd (GL)	GL19740 11 HH00
American Bureau of Shipping (ABS)	ABS_11_HG 789392_PDA
Bureau Veritas (BV)	BV 271007A0 BV
Det Norske Veritas (DNV)	A 12553
Drinking water approval (ACS)	ACS 11 ACC NY 055
GOST	GOST-R
Underwriters Laboratories (UL)	
• for USA and Canada	UL 20110217 - E34453
• worldwide	IEC UL DK 21845
Explosion protection	
Intrinsic safety "i" (only with current output)	Ex II 1/2 G Ex ia IIC T4 Ga/Gb Ex II 1/2 D Ex ia IIIC T125 °C Da/Db
EC type-examination certificate	SEV 10 ATEX 0146
Connection to certified intrinsically-safe resistive circuits with maximum values:	$U_i \leq 30\text{ V DC}$; $I_i \leq 100\text{ mA}$; $P_i \leq 0.75\text{ W}$
Effective internal inductance and capacity for versions with plugs per EN 175301-803-A and M12	$L_i = 0\text{ nH}$; $C_i = 0\text{ nF}$

Pressure Measurement

Transmitters for basic requirements

SITRANS P220 for gauge pressure

Selection and ordering data

SITRANS P 220 pressure transmitters for gauge pressure, high-pressure and refrigeration applications, fully-welded version

Accuracy typ. 0.25 %

Wetted parts materials: stainless steel

Non-wetted parts materials: stainless steel

➤ Click on the Article No. for the online configuration in the PIA Life Cycle Portal.

Article No.

Order code

7MF1567 - - - - - A - - - - -

Measuring range

Overload limit

Mini-
mum

Max.

Burst pressure

For gauge pressure

0 ... 2.5 bar	(0 ... 36.3 psi)	-1 bar	(-14.5 psi)	6.25 bar	(90.7 psi)	25 bar	(363 psi)	▶	3BD
0 ... 4 bar	(0 ... 58 psi)	-1 bar	(-14.5 psi)	10 bar	(145 psi)	40 bar	(870 psi)	▶	3BE
0 ... 6 bar	(0 ... 87 psi)	-1 bar	(-14.5 psi)	15 bar	(217 psi)	60 bar	(522 psi)	▶	3BG
0 ... 10 bar	(0 ... 145 psi)	-1 bar	(-14.5 psi)	25 bar	(362 psi)	60 bar	(870 psi)	▶	3CA
0 ... 16 bar	(0 ... 232 psi)	-1 bar	(-14.5 psi)	40 bar	(580 psi)	96 bar	(1392 psi)	▶	3CB
0 ... 25 bar	(0 ... 363 psi)	-1 bar	(-14.5 psi)	62.5 bar	(906 psi)	150 bar	(2176 psi)	▶	3CD
0 ... 40 bar	(0 ... 580 psi)	-1 bar	(-14.5 psi)	100 bar	(1450 psi)	240 bar	(3481 psi)	▶	3CE
0 ... 60 bar	(0 ... 870 psi)	-1 bar	(-14.5 psi)	150 bar	(2175 psi)	360 bar	(5221 psi)	▶	3CG
0 ... 100 bar	(0 ... 1450 psi)	-1 bar	(-14.5 psi)	250 bar	(3625 psi)	600 bar	(8702 psi)	▶	3DA
0 ... 160 bar	(0 ... 2320 psi)	-1 bar	(-14.5 psi)	400 bar	(5801 psi)	960 bar	(13924 psi)	▶	3DB
0 ... 250 bar	(0 ... 3625 psi)	-1 bar	(-14.5 psi)	625 bar	(9064 psi)	1500 bar	(21756 psi)	▶	3DD
0 ... 400 bar	(0 ... 5801 psi)	-1 bar	(-14.5 psi)	1000 bar	(14503 psi)	2400 bar	(34809 psi)	▶	3DE
0 ... 600 bar	(0 ... 8702 psi)	-1 bar	(-14.5 psi)	1500 bar	(21755 psi)	2500 bar	(36260 psi)	▶	3DG

Other version, add Order code and plain text:

Measuring range: ... up to ... bar (psi)

Measuring ranges for gauge pressure (only for US market)

(0 ... 30 psi)	(-14.5 psi)	(75 psi)	(360 psi)	4BE
(0 ... 60 psi)	(-14.5 psi)	(150 psi)	(580 psi)	4BF
(0 ... 100 psi)	(-14.5 psi)	(250 psi)	(580 psi)	4BG
(0 ... 150 psi)	(-14.5 psi)	(375 psi)	(870 psi)	4CA
(0 ... 200 psi)	(-14.5 psi)	(500 psi)	(1390 psi)	4CB
(0 ... 300 psi)	(-14.5 psi)	(750 psi)	(2170 psi)	4CD
(0 ... 500 psi)	(-14.5 psi)	(1250 psi)	(3480 psi)	4CE
(0 ... 750 psi)	(-14.5 psi)	(1875 psi)	(5220 psi)	4CF
(0 ... 1000 psi)	(-14.5 psi)	(2500 psi)	(5220 psi)	4CG
(0 ... 1500 psi)	(-14.5 psi)	(3750 psi)	(8700 psi)	4DA
(0 ... 2000 psi)	(-14.5 psi)	(5000 psi)	(13920 psi)	4DB
(0 ... 3000 psi)	(-14.5 psi)	(7500 psi)	(21750 psi)	4DD
(0 ... 5000 psi)	(-14.5 psi)	(12500 psi)	(34800 psi)	4DE
(0 ... 6000 psi)	(-14.5 psi)	(15000 psi)	(34800 psi)	4DF
(0 ... 8700 psi)	(-14.5 psi)	(21000 psi)	(52200 psi)	4DG

Other version, add Order code and plain text: Measuring range: ... up to ... psi

Output signal

4 ... 20 mA; two-wire system; power supply 7 ... 33 V DC (10 ... 30 V DC for ATEX versions)

0 ... 10 V; three-wire system; power supply 12 ... 33 V DC

Explosion protection (only 4 ... 20 mA)

None

With explosion protection Ex ia IIC T4

Electrical connection

Connector per DIN EN 175301-803-A, stuffing box thread M16 (with coupling)

Round connector M12 per IEC 61076-2-101 (not for gauge pressure ranges ≤ 16 bar)

Connection via fixed mounted cable, 2 m (not for type of protection "Intrinsic safety i")

Quickon cable quick screw connection PG9 (not for type of protection "Intrinsic safety i")

Connector per DIN EN 175301-803-A, stuffing box thread 1/2"-14 NPT (with coupling)

Connector per DIN EN 175301-803-A, stuffing box thread PG11 (with coupling)

Fixed mounted cable, length 5 m

Special version

➤ Available ex stock

➤ We can offer shorter delivery times for configurations designated with the Quick Ship Symbol ➤. For details see page 9/5 in the appendix.

Pressure Measurement

Transmitters for basic requirements

SITRANS P220 for gauge pressure

1

Selection and ordering data

SITRANS P 220 pressure transmitters for gauge pressure, high-pressure and refrigeration applications, fully-welded version

Accuracy typ. 0.25 %

Wetted parts materials: stainless steel

Non-wetted parts materials: stainless steel

Process connection

G½" male per EN 837-1 (½" BSP male) (standard for metric pressure ranges mbar, bar)

G½" male thread and G1/8" female thread

G¼" male per EN 837-1 (¼" BSP male)

7/16"-20 UNF male

¼"-18 NPT male (standard for pressure ranges inH₂O and psi)

¼"-18 NPT female (Only for measuring ranges ≤ 60 bar (870 psi))

½"-14 NPT male

½"-14 NPT female (Only for measuring ranges ≤ 60 bar (870 psi))

7/16"-20 UNF female

M20x1.5 male

Special version

Version

Standard version

Further designs

Supplement the Article No. with "-Z" and add Order code.

Manufacturer's test certificate M per IEC 60770-2 (calibration certificate) supplied

Oxygen application, oil and grease-free cleaning (Not in conjunction with explosion protection version)

► Available ex stock

◆ We can offer shorter delivery times for configurations designated with the Quick Ship Symbol ◆. For details see page 9/5 in the appendix.

Article No.

Order code

7MF1567-

A

A

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P1Y

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C11

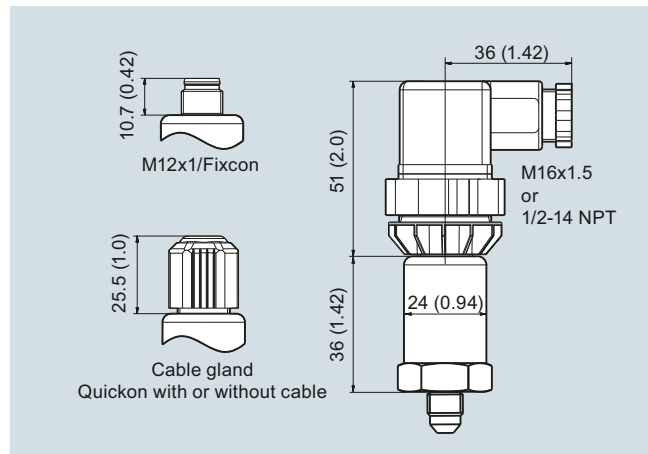
E10

Pressure Measurement

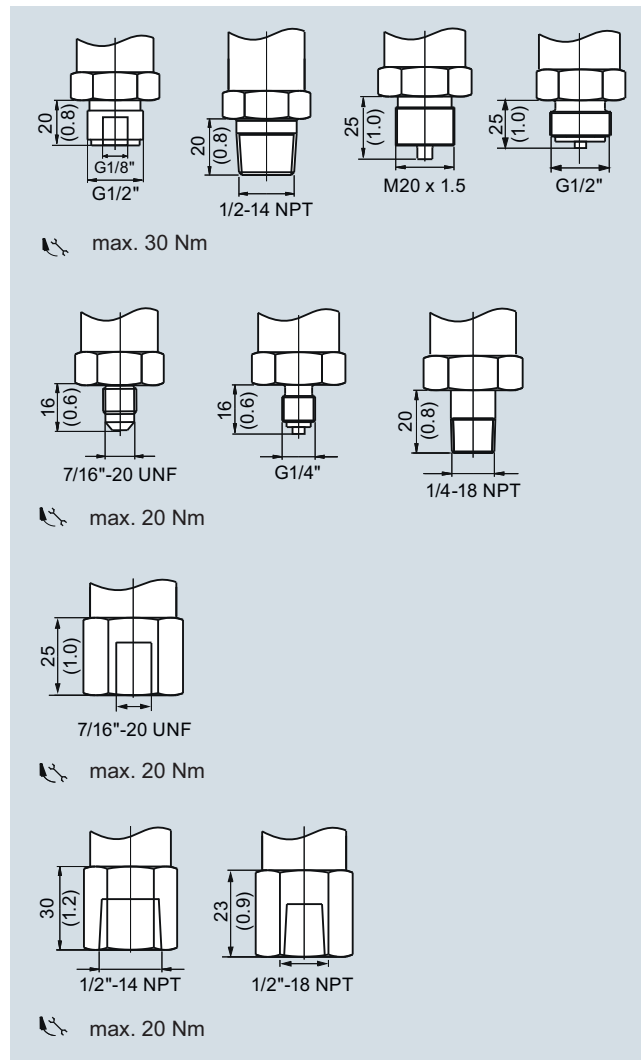
Transmitters for basic requirements

SITRANS P220 for gauge pressure

Dimensional drawings



SITRANS P220, electrical connections, dimensions in mm (inch)



SITRANS P220, process connections, dimensions in mm (inch)

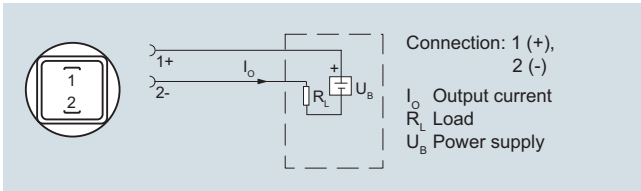
Pressure Measurement

Transmitters for basic requirements

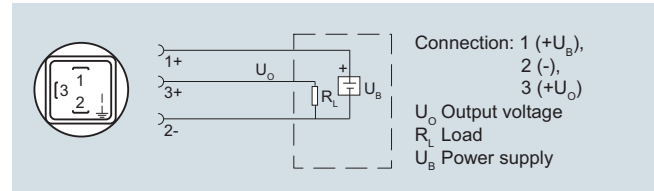
SITRANS P220 for gauge pressure

1

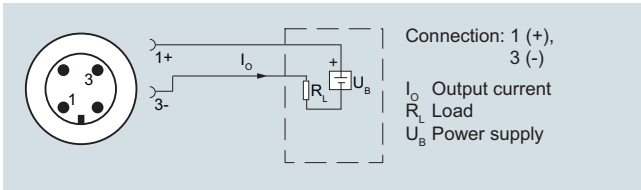
Schematics



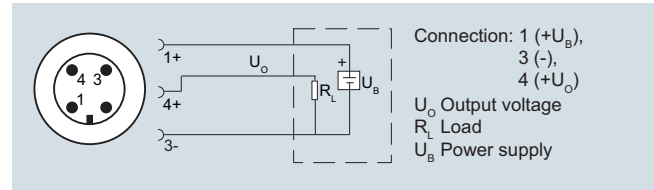
Connection with current output and connector per EN 175301



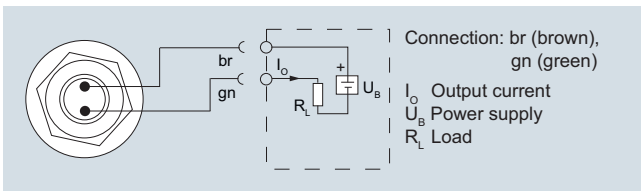
Connection with voltage output and connector per EN 175301



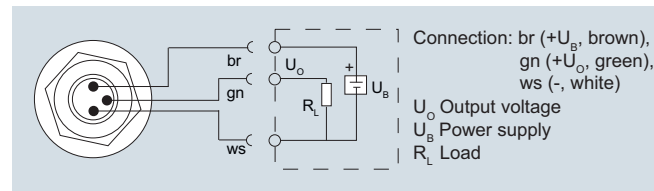
Connection with current output and connector M12x1



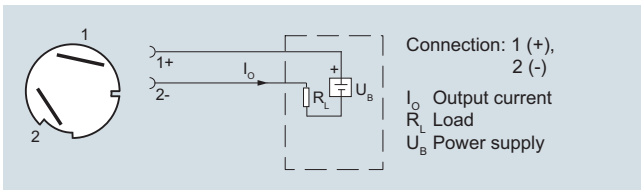
Connection with voltage output and connector M12x1



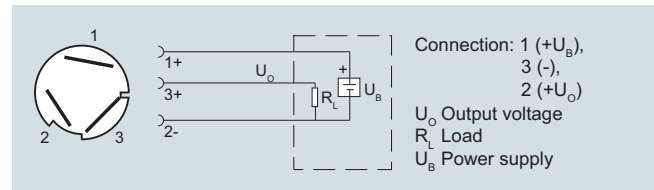
Connection with current output and cable



Connection with voltage output and cable



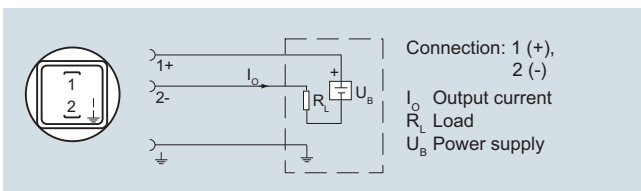
Connection with current output and cable quick screw connection Quickon



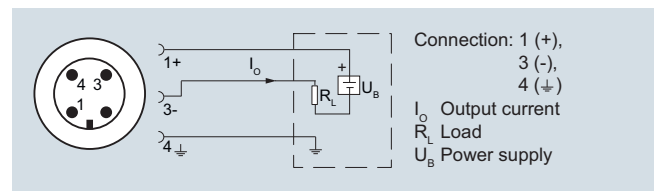
Connection with voltage output and cable quick screw connection Quickon

Version with explosion protection: 4 ... 20 mA

The grounding connection is conductively bonded to the transmitter enclosure



Connection with current output and connector per EN 175301 (Ex)



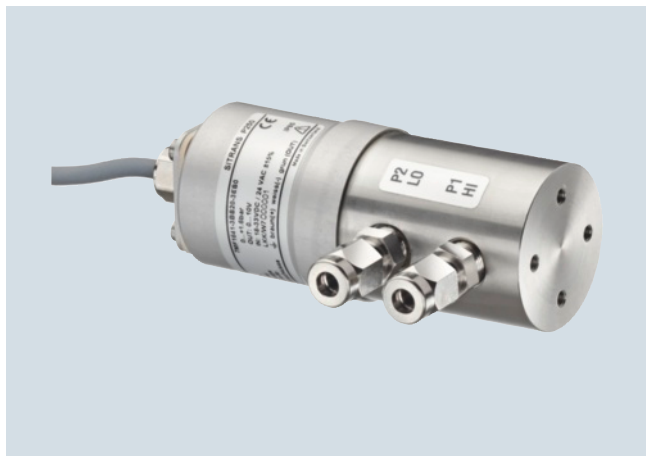
Connection with current output and connector M12x1 (Ex)

Pressure Measurement

Transmitters for basic requirements

SITRANS P250 for differential pressure

Overview



The SITRANS P250 transmitter measures the differential pressure of liquids and gases.

Benefits

- High measuring accuracy
- Sturdy stainless steel enclosure
- For aggressive and non-aggressive media
- For the measurement of the differential pressure of liquids and gases
- Temperature-compensated measuring cell
- Compact design

Application

The SITRANS P250 transmitter for differential pressure is primarily used in the following industries:

- Chemical industry
- Heating, ventilation and air conditioning technology
- Food industry
- Mechanical engineering
- Shipbuilding
- Water supply

Design

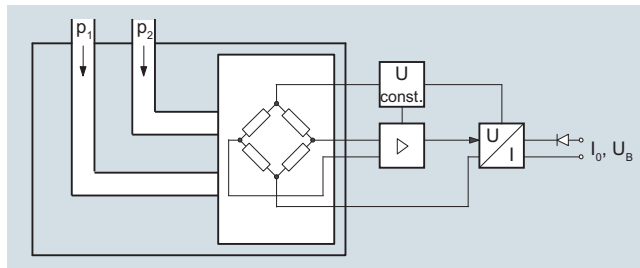
Main components:

- Stainless steel enclosure with piezo-resistive ceramic measuring cell (temperature-compensated) and electronics module
- Process connection made of stainless steel in diverse designs (see Selection and Ordering data)
- Electrical connection through connectors acc. to EN 175301-803-A and round connectors M12, as well as with permanently fixed cable

Function

The pressure transmitter measures the differential pressure of liquids and gases.

Mode of operation



SITRANS P250 pressure transmitter, function diagram

The piezo-resistive measuring cell (ceramic membrane) has a Wheatstone bridge circuit, on which the operating pressure P1 and P2 of the media acts at both ends.

The voltage output from the measuring cell is converted by an amplifier into an output current of 4 to 20 mA or an output voltage of 0 to 5 or 10 V DC.

The output current and voltage are linearly proportional to the input pressure.

Technical specifications

SITRANS P250 differential pressure transmitter	
Application	
Differential pressure transmitter	Liquids and neutral gases
Mode of operation	
Measuring principle	Piezo-resistive measuring cell (ceramic diaphragm)
Input	
Measured variable	Differential pressure
Measuring range	0 ... 0.1 to 0 ... 25 bar (0 ... 1.45 to 0 ... 363 psi)
Operating pressure	≤ 25 bar at a differential pressure range > 6 bar ≤ 50 bar at a differential pressure range > 10 bar
Burst pressure	1.5 x operating pressure
Output	
Output signal	
• Current output signal	4 ... 20 mA
• Voltage output signal	0 ... 5 V DC and 0 ... 10 V DC
Load	
• 3-wire	> 10 kΩ
• 2-wire	≤ (U _H - 11 V) / 0.02 A
Measuring accuracy	
Error in measurement at limit setting incl. hysteresis and reproducibility	≤ 1 % of typical full-scale value, see "Measuring range" table
Long-term stability acc. to IEC 60770	≤ 0.5 % of full-scale value/year
Influence of ambient temperature	
• Start of scale	≤ 0.6 % / 10 K of full-scale value (≤ 1.2 % / 10K for measuring cell 0 ... 0.1 bar (1.45 psi))
• Full-scale value	≤ 0.22 % / 10 K of full-scale value (≤ 0.37 % / 10K for measuring cell 0 ... 0.1 bar (1.45 psi))
Dynamic behavior	Suitable for static and dynamic measurements
Step response time T ₉₉	< 5 ms
Load variation	< 50 Hz

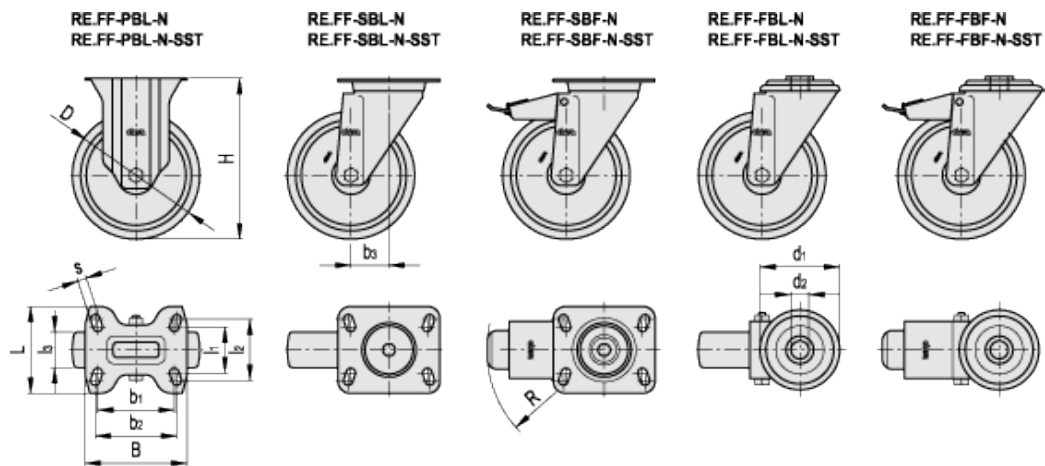
Prilog 13: Kotači

RE.FF-N

Injected polyurethane wheels with steel sheet bracket



INOX
Stainless Steel



technical informations

Covering

Injected polyurethane, hardness 55 Shore D.

Wheel centre body

Polyamide-based technopolymer (PA). Resistant to solvents, oils, greases and other chemical agents.

Hub

Directly made into the centre.

Axle set

Calibrated precision tube. The tube serves as a spacer, is tightened to the bracket with screw and nut to a un predetermined torque value.
The wheel hub rotates onto the tube freely.

Standard executions

- PBL-N: brakeless wheel with zinc-plated steel bracket, fixed plate.
- SBL-N: brakeless wheel with zinc-plated steel bracket, turning plate.
- SBF-N: wheel with zinc-plated steel bracket, turning plate, with brake.
- FBL-N: brakeless wheel with zinc-plated steel bracket, turning plate and central pass-through hole.
- FBF-N: wheel with zinc-plated steel bracket, turning plate and central pass-through hole, with brake.
- PBL-N-SST: brakeless wheel with stainless steel bracket, fixed plate.
- SBL-N-SST: brakeless wheel with stainless steel bracket, turning plate.
- SBF-N-SST: wheel with stainless steel bracket, turning plate, with brake.
- FBL-N-SST: brakeless wheel with stainless steel bracket, turning plate and central pass-through hole.
- FBF-N-SST: wheel with stainless steel bracket, turning plate and central pass-through hole, with brake.

Fixed plate bracket

Zinc-plated steel or AISI 304 stainless steel (SST version) sheet, the bracket is designed to withstand loads up to 3000N.

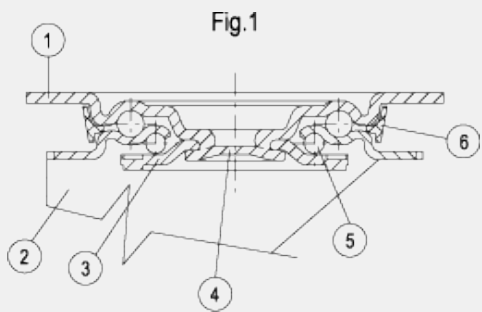
Turning plate bracket

Zinc-plated steel or AISI 304 stainless steel (SST version) sheet, the bracket is designed to withstand loads up to 3000N.

The presence of two ball turns and the direct contact between the plate and the ball race ring with built-in pin ensure excellent manoeuvrability and very limited clearance (see fig. 1).

Does not require maintenance. It consists of:

- 1) fitting plate: electrolytically zinc-plated steel or AISI 304 stainless steel sheet;
- 2) fork: electrolytically zinc-plated steel or AISI 304 stainless steel sheet;
- 3) ball race ring: electrolytically zinc-plated steel or AISI 304 stainless steel sheet;
- 4) central pin: incorporated in the plate, cold reflanged;
- 5) rotation system: dual grease-lubricated ring of ball;
- 6) dust seal: RAL 7015 dark grey technopolymer.



Front-actuated brake

Total brake that locks the wheel and bracket rotation.

The optimised dimensions and the retractable pedal ensure minimal space occupied and maximum actuation ease. Hardened carbon steel or stainless steel (SST version) spring.

The trolley must be turned to use the device.

The brake is simple and effective to use: it is actuated and released by a simple action from the top downward at the tip of two separate pedals, thus ensuring the utmost manoeuvring comfort. The braking efficacy may be adjusted with a socket head screw M8.

Applications

Excellent rolling resistance and elasticity, good wear and tearing resistance. For further information see [RE.FF](#) wheel.



Standard Elements		Main dimensions														Rolling resistance #	Dynamic carrying capacity #	Weight
Code	Description	D	I ₃	H	B	L	s	b ₁	l ₁	b ₂	l ₂	b ₃	R	d ₁	d ₂	[N]	[N]	g
451151	RE.FF-080-PBL-N	80	30	107	100	85	9	75	45	80	60	-	-	-	-	1200	1200	380
451156	RE.FF-100-PBL-N	100	30	128	100	85	9	75	45	80	60	-	-	-	-	1700	1700	430
451161	RE.FF-125-PBL-N	125	35	156	100	85	9	75	45	80	60	-	-	-	-	2300	2200	660
451166	RE.FF-150-PBL-N	150	45	194	140	114	11	105	73	105	85	-	-	-	-	2800	3000	1460
451051	RE.FF-080-SBL-N	80	30	107	100	85	9	75	45	80	60	39	-	-	-	1200	1200	620
451056	RE.FF-100-SBL-N	100	30	128	100	85	9	75	45	80	60	35	-	-	-	1700	1700	740
451061	RE.FF-125-SBL-N	125	35	156	100	85	9	75	45	80	60	37	-	-	-	2300	2200	910
451066	RE.FF-150-SBL-N	150	45	194	140	110	11	105	73	105	87	56	-	-	-	2800	3000	1830
451101	RE.FF-080-SBF-N	80	30	107	100	85	9	75	45	80	60	39	120	-	-	1200	1200	810
451106	RE.FF-100-SBF-N	100	30	128	100	85	9	75	45	80	60	35	120	-	-	1700	1700	890
451111	RE.FF-125-SBF-N	125	35	156	100	85	9	75	45	80	60	37	120	-	-	2300	2200	1050
451116	RE.FF-150-SBF-N	150	45	194	140	110	11	105	73	105	87	56	156	-	-	2800	3000	2110
451171	RE.FF-80-FBL-N	80	30	107	-	-	-	-	-	-	-	39	-	73	12	1200	1200	550
451173	RE.FF-100-FBL-N	100	30	128	-	-	-	-	-	-	-	35	-	73	12	1700	1700	670
451176	RE.FF-125-FBL-N	125	35	156	-	-	-	-	-	-	-	37	-	73	12	2300	2200	850
451179	RE.FF-150-FBL-N	150	45	188	-	-	-	-	-	-	-	56	-	102	20	2800	3000	1690
451181	RE.FF-80-FBF-N	80	30	107	-	-	-	-	-	-	-	39	120	73	12	1200	1200	730
451183	RE.FF-100-FBF-N	100	30	128	-	-	-	-	-	-	-	35	120	73	12	1700	1700	880
451186	RE.FF-125-FBF-N	125	35	156	-	-	-	-	-	-	-	37	120	73	12	2300	2200	1000
451189	RE.FF-150-FBF-N	150	45	188	-	-	-	-	-	-	-	56	156	102	20	2800	3000	1980

See [Technical Data](#) for rolling resistance and dynamic carrying capacity.

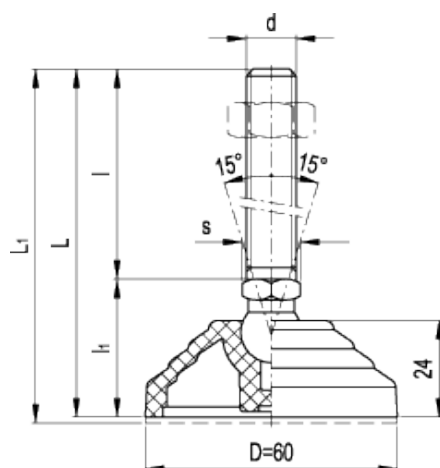
Prilog 14: Vijci za nivelaciju

LV.A

Levelling elements



ELESA Original design



technical informations

Base

Glass-fibre reinforced polyamide based (PA) technopolymer. Resistant to solvents, oils, greases and other chemical agents.

Colour

Black, matte finish.

Articulated stem

Threaded zinc-plated steel and regulation hexagon.

No-slip disk

NBR synthetic rubber, hardness 70 Shore A.

- LV.A: without no-slip disk.

- LV.A-AS: with no-slip disk, supplied assembled.

Accessories on request

Zinc-plated steel nut to be ordered separately (see Nuts [NT.](#)).

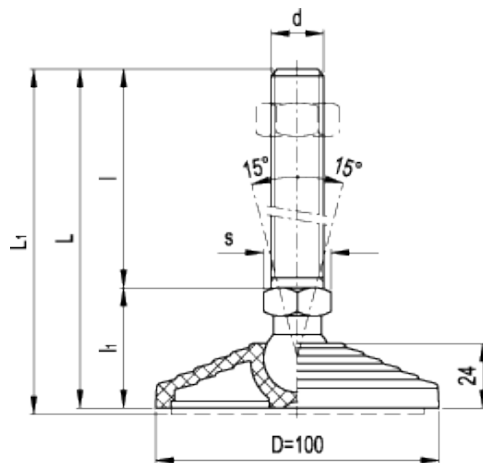
Features and applications

The light knurling under the lower lip of the levelling element provides excellent stability and grip when using the levelling element without no-slip disk even on surfaces that are not perfectly flat.
The particular configuration of bases and no-slip disks assures a strong assembly, preventing separation in case of strong impact or adhesion with the floor (see [No-slip disks](#)).

Order information

To order bases and stems separately, see the [table of the possible combinations Bases/Stems](#).
The levelling element is supplied unassembled to make carriage and storage easier; the components are in separate packing: less volume taken and better protection from scratches and dirt.

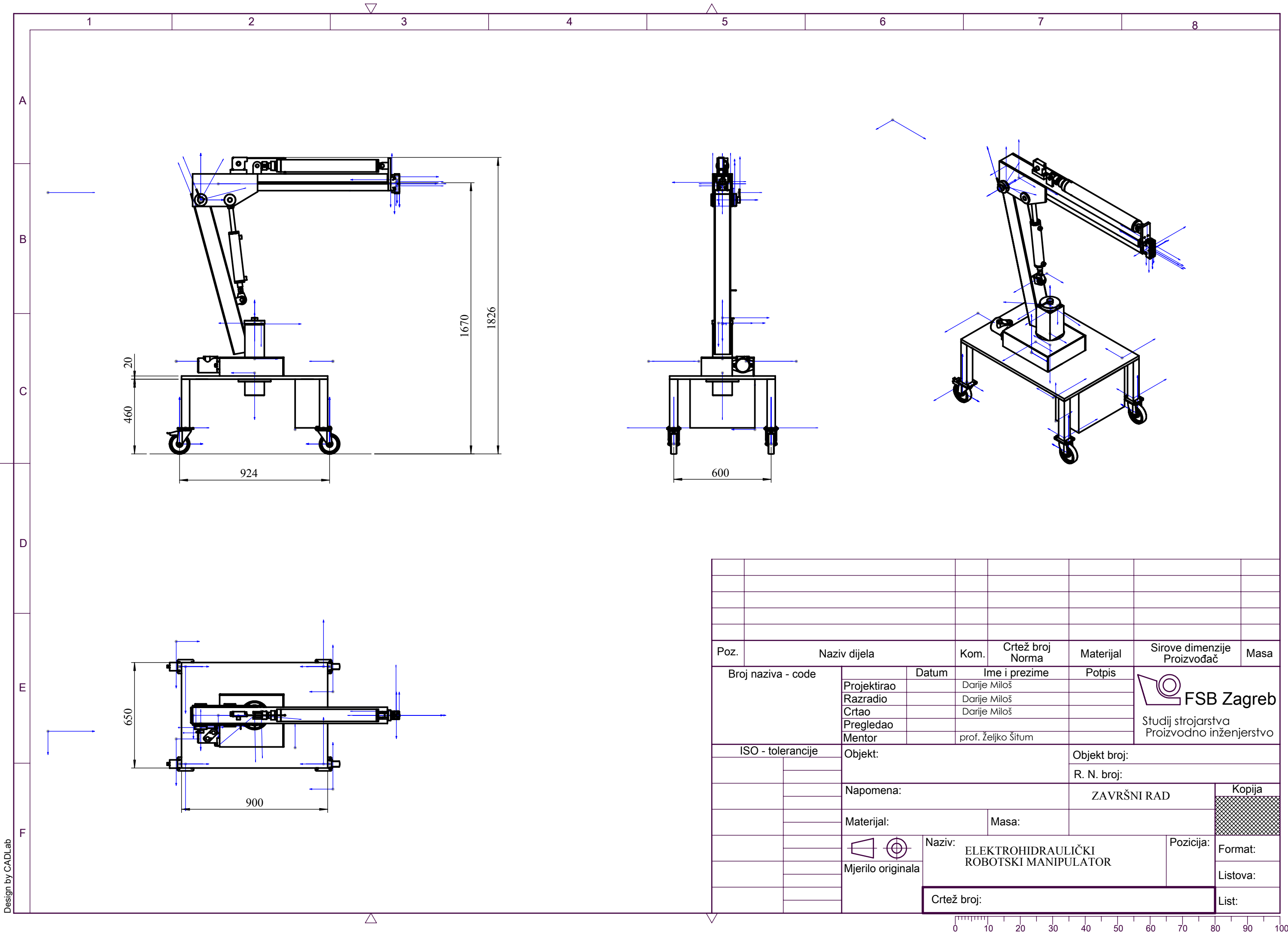
Without no-slip disk	With no-slip disk	Main dimensions	Threaded stem	Articulation	Wrench	Max limit static load*	Weig
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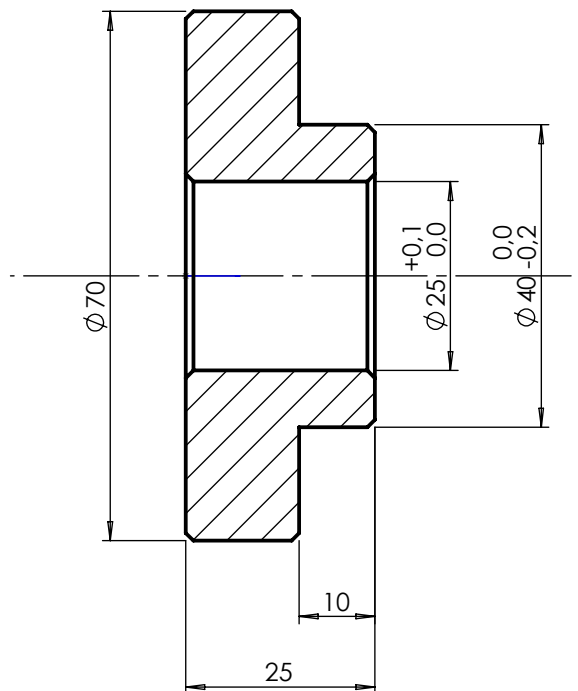
Without no-slip disk	With no-slip disk	Main dimensions	Threaded stem	Articulation	Wrench	Max limit static load*	Weig
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Code	Description	Code	Description	D	L	L _{1#}	I ₁	d	l	Ø	s	[N]	g	g
305451	LV.A-100-14-M8x43	309451	LV.A-100-14-AS-M8x43	100	76	79	33	M8	43	14	14	18000	91	1
305453	LV.A-100-14-M8x68	309453	LV.A-100-14-AS-M8x68	100	101	104	33	M8	68	14	14	18000	103	1
305461	LV.A-100-14-M10x43	309461	LV.A-100-14-AS-M10x43	100	76	79	33	M10	43	14	14	18000	100	1
305463	LV.A-100-14-M10x68	309463	LV.A-100-14-AS-M10x68	100	101	104	33	M10	68	14	14	18000	112	1
305465	LV.A-100-14-M10x98	309465	LV.A-100-14-AS-M10x98	100	131	134	33	M10	98	14	14	18000	126	1
305471	LV.A-100-14-M12x43	309471	LV.A-100-14-AS-M12x43	100	76	79	33	M12	43	14	14	18000	110	1
305473	LV.A-100-14-M12x68	309473	LV.A-100-14-AS-M12x68	100	101	104	33	M12	68	14	14	18000	127	1
305475	LV.A-100-14-M12x98	309475	LV.A-100-14-AS-M12x98	100	131	134	33	M12	98	14	14	18000	148	2
305481	LV.A-100-14-M16x68	309481	LV.A-100-14-AS-M16x68	100	101	104	33	M16	68	14	16	18000	171	2
305483	LV.A-100-14-M16x108	309483	LV.A-100-14-AS-M16x108	100	141	144	33	M16	108	14	16	18000	223	2
305485	LV.A-100-14-M16x148	309485	LV.A-100-14-AS-M16x148	100	181	184	33	M16	148	14	16	18000	275	3
305487	LV.A-100-14-M16x168	309487	LV.A-100-14-AS-M16x168	100	201	204	33	M16	168	14	16	18000	301	3
305521	LV.A-100-24-M16x58	309521	LV.A-100-24-AS-M16x58	100	101	104	43	M16	58	24	24	25000	251	3
305525	LV.A-100-24-M16x98	309525	LV.A-100-24-AS-M16x98	100	141	144	43	M16	98	24	24	25000	302	3
305541	LV.A-100-24-M16x138	309541	LV.A-100-24-AS-M16x138	100	181	184	43	M16	138	24	24	25000	352	4
305561	LV.A-100-24-M16x158	309561	LV.A-100-24-AS-M16x158	100	201	204	43	M16	158	24	24	25000	379	4
305625	LV.A-100-24-M20x98	309625	LV.A-100-24-AS-M20x98	100	141	144	43	M20	98	24	24	25000	372	4
305641	LV.A-100-24-M20x138	309641	LV.A-100-24-AS-M20x138	100	181	184	43	M20	138	24	24	25000	451	5
305661	LV.A-100-24-M20x158	309661	LV.A-100-24-AS-M20x158	100	201	204	43	M20	158	24	24	25000	490	5
305681	LV.A-100-24-M20x198	309681	LV.A-100-24-AS-M20x198	100	241	244	43	M20	198	24	24	25000	573	6
305725	LV.A-100-24-M24x98	309725	LV.A-100-24-AS-M24x98	100	141	144	43	M24	98	24	24	25000	470	5
305761	LV.A-100-24-M24x158	309761	LV.A-100-24-AS-M24x158	100	201	204	43	M24	158	24	24	25000	642	6
305781	LV.A-100-24-M24x198	309781	LV.A-100-24-AS-M24x198	100	241	244	43	M24	198	24	24	25000	760	8

* "Max limit static load" means the value over which the applied load to the element, in certain conditions of use, may cause plastic material deformation. # Data with no-slip disk mounted.

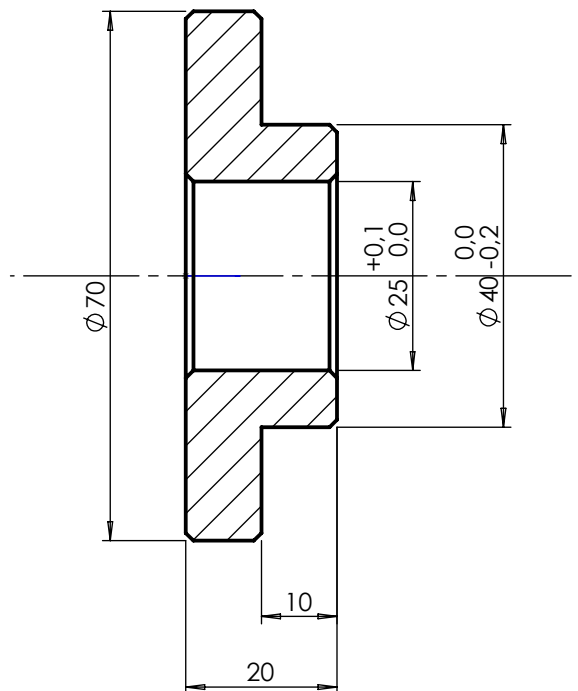


A-A



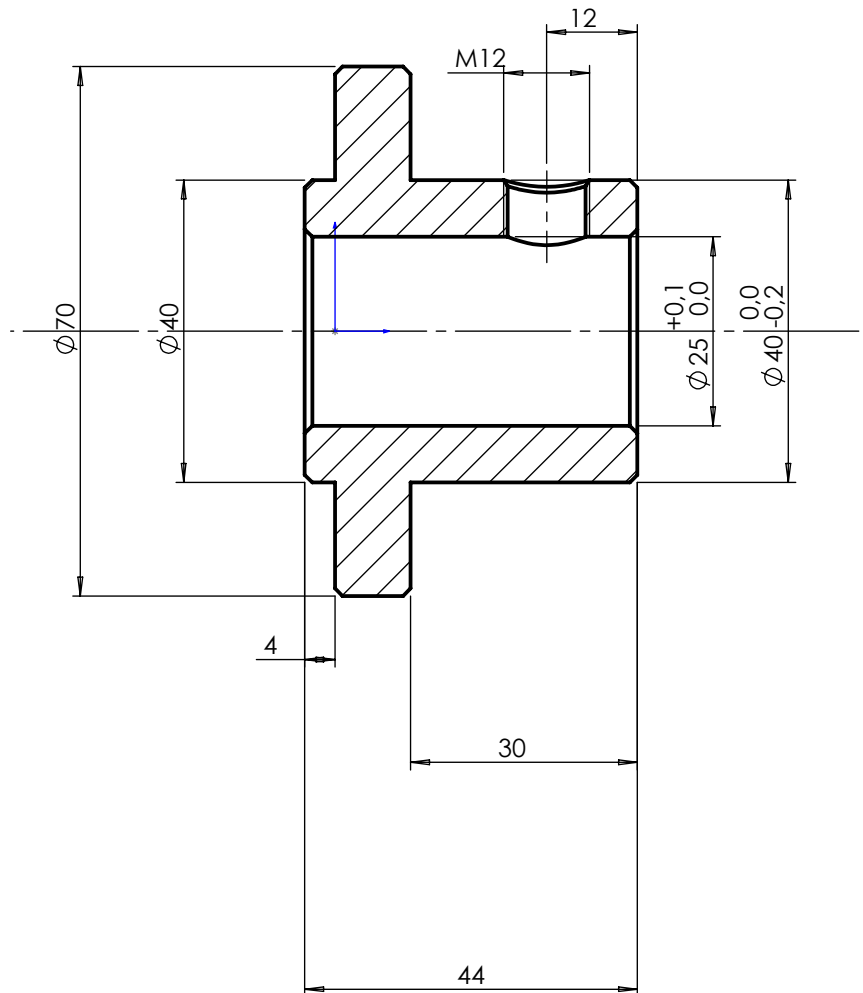
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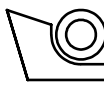
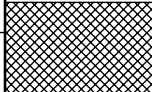
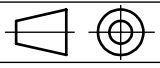
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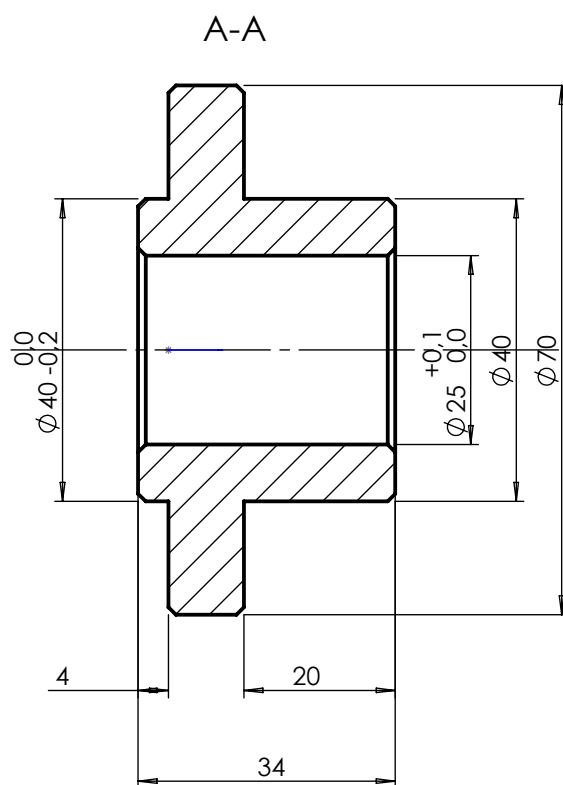


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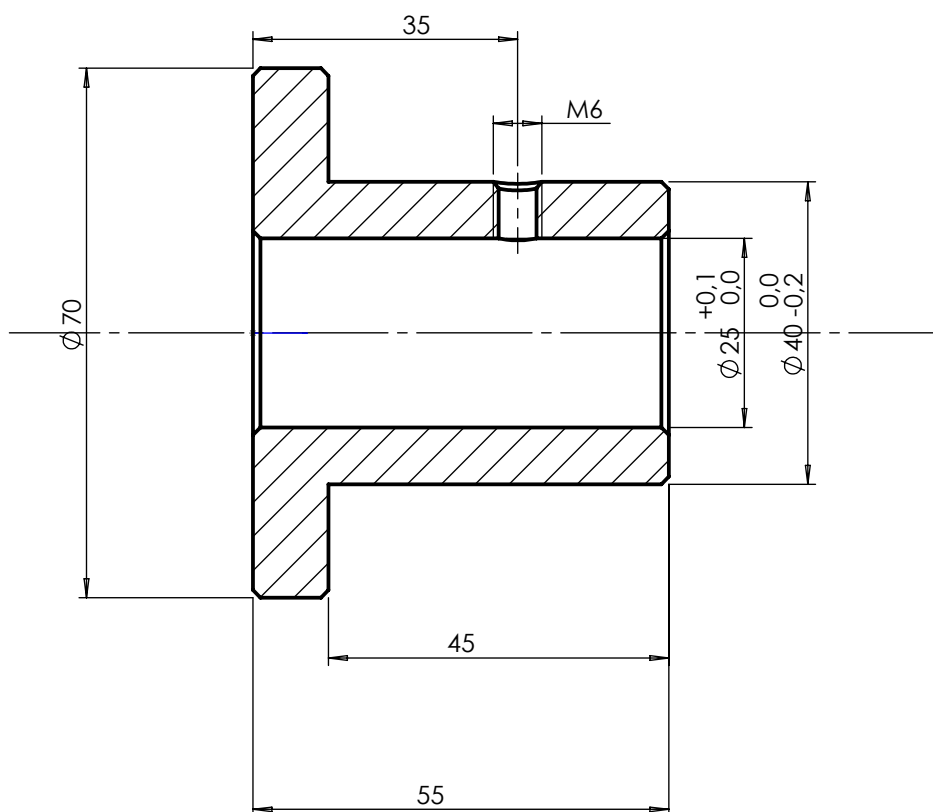
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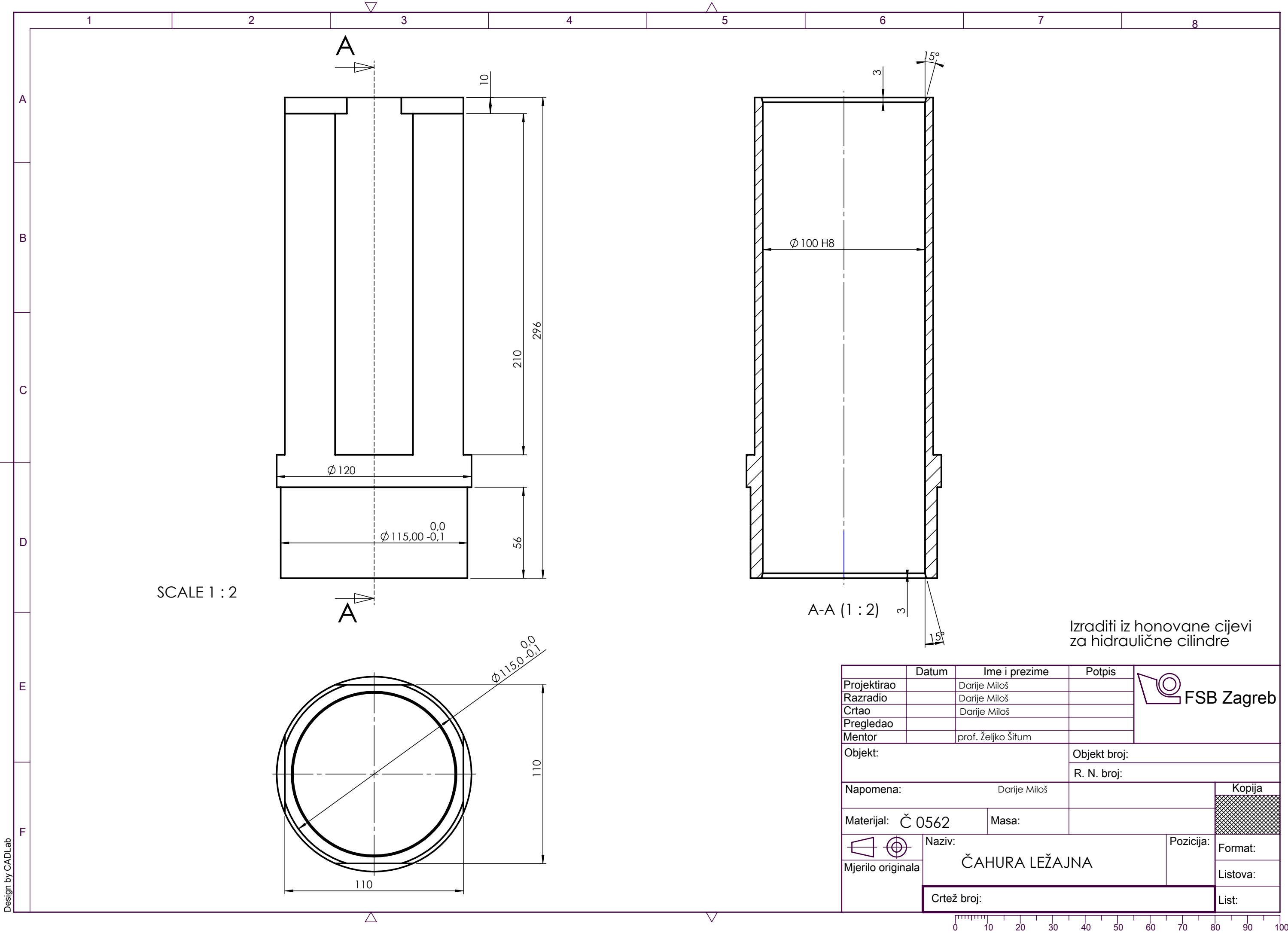
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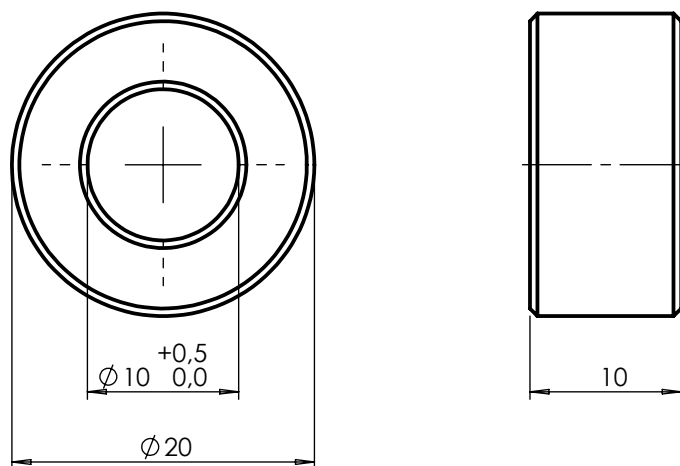


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ISO - tolerancije	Objekt:			Objekt broj:	
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	Mjerilo originala			ČAHURA	Format:
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Broj naziva - code	Projektirao	Datum	Ime i prezime	Potpis	 FSB Zagreb
	Razradio		Darije Miloš		
	Crtao		Darije Miloš		
	Pregledao				
			prof. željko Šitum		
ISO - tolerancije	Objekt:			Objekt broj:	
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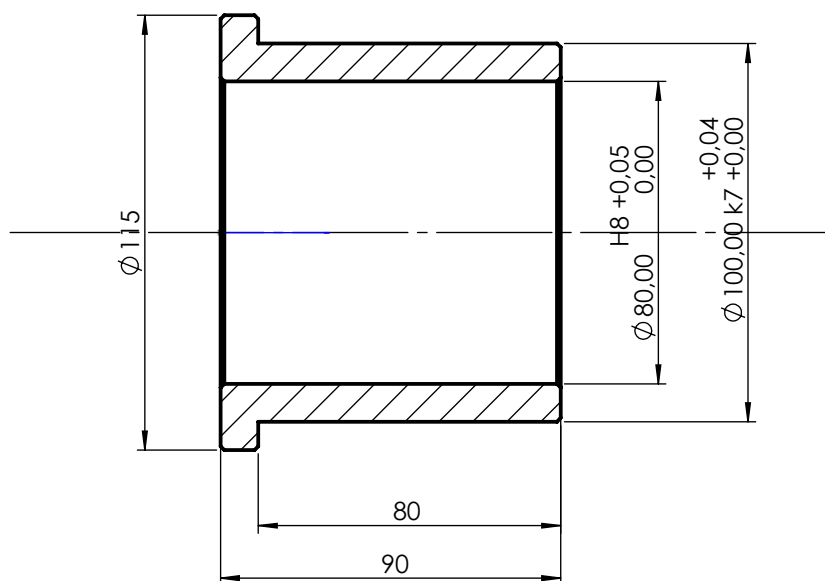


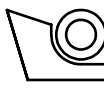
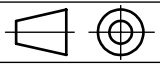


Design by CADLab

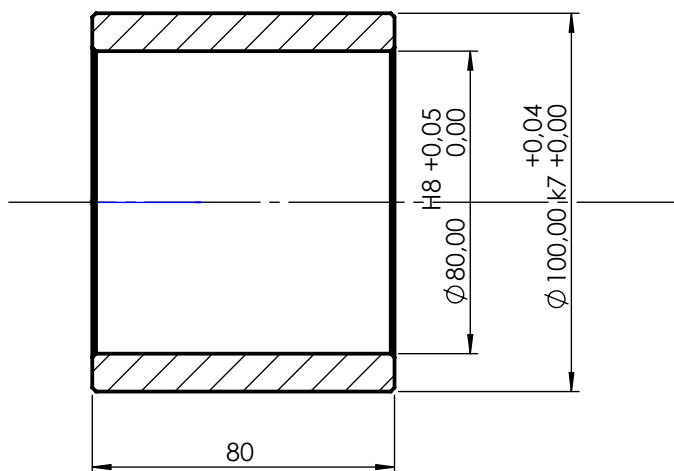
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		Razradio		Darije Miloš					
		Crtao		Darije Miloš					
		Pregledao		prof. Željko Šitum					
ISO - tolerancije		Objekt:				Objekt broj:			
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						Crtež broj:			

A-A (1 : 2)



Broj naziva - code	Projektirao	Datum	Ime i prezime	Potpis	 FSB Zagreb
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	Crtao		Darije Miloš		
	Pregledao				
			prof. Željko Šitum		
ISO - tolerancije	Objekt:			Objekt broj:	
				R. N. broj:	
	Napomena:				
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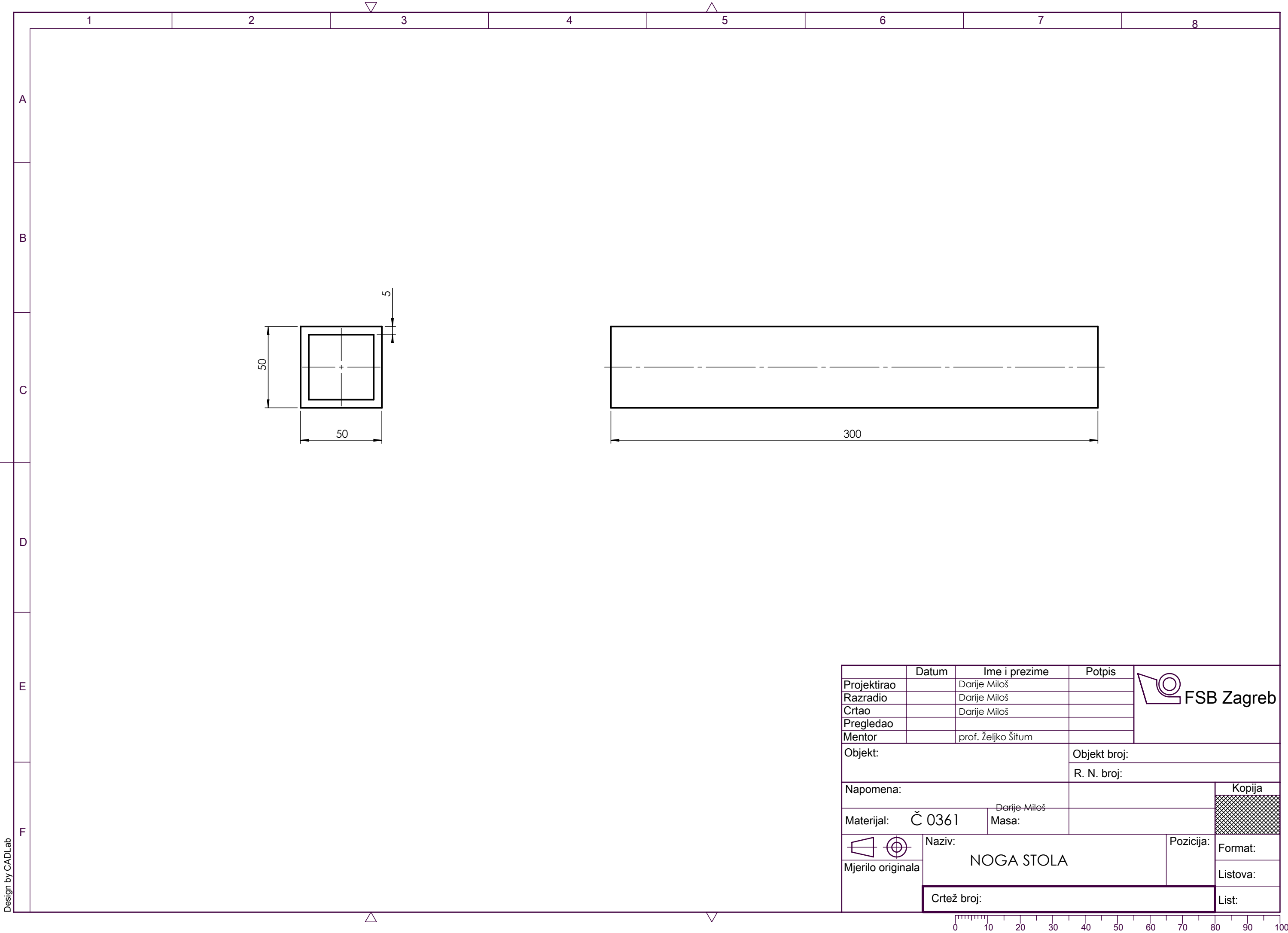
A-A (1 : 2)



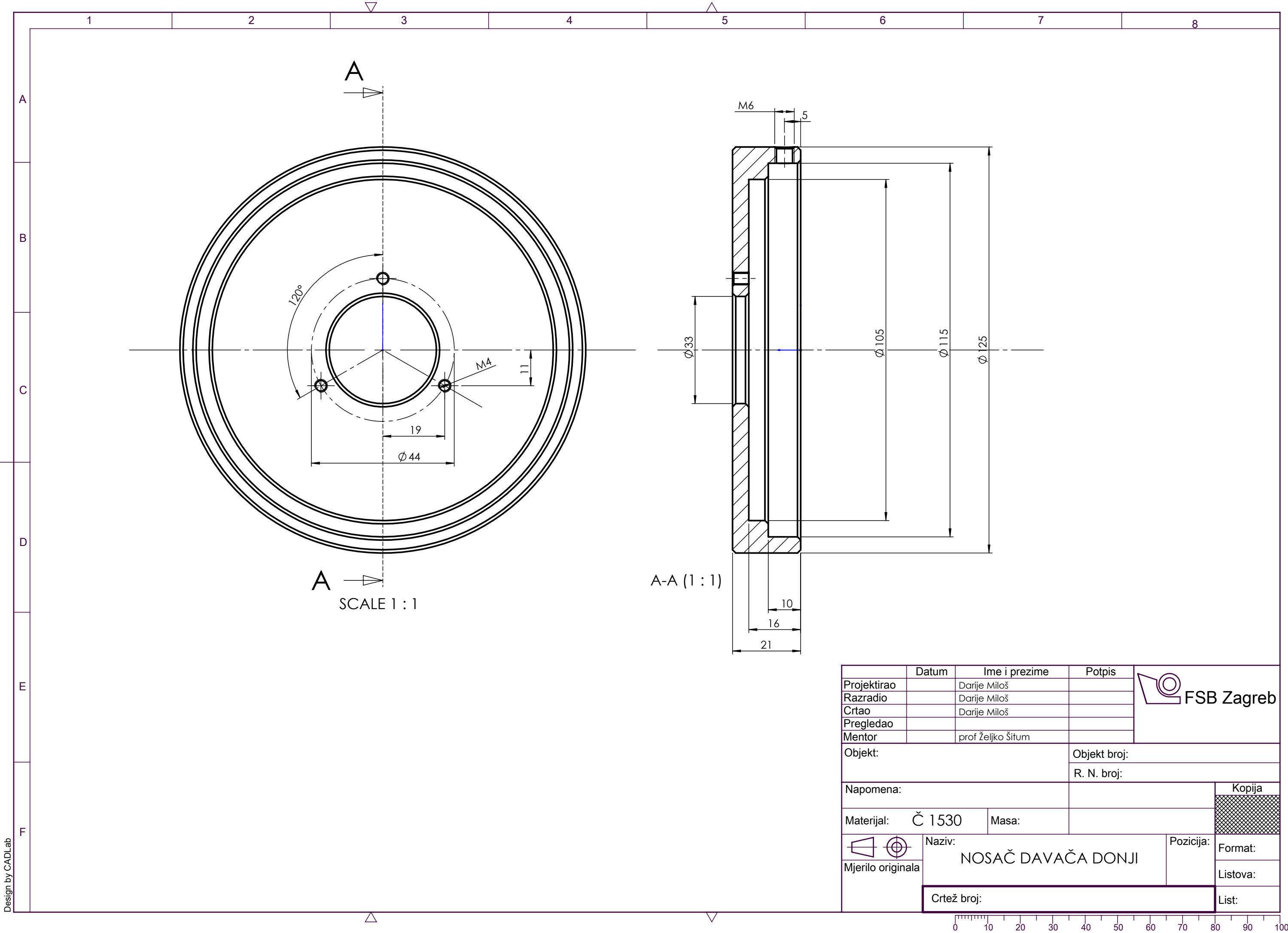
Broj naziva - code	Projektirao	Datum	Ime i prezime	Potpis	 FSB Zagreb
	Razradio		Darije Miloš		
	Crtao		Darije Miloš		
	Pregledao				
			prof. Željko Šitum		
ISO - tolerancije	Objekt:			Objekt broj:	
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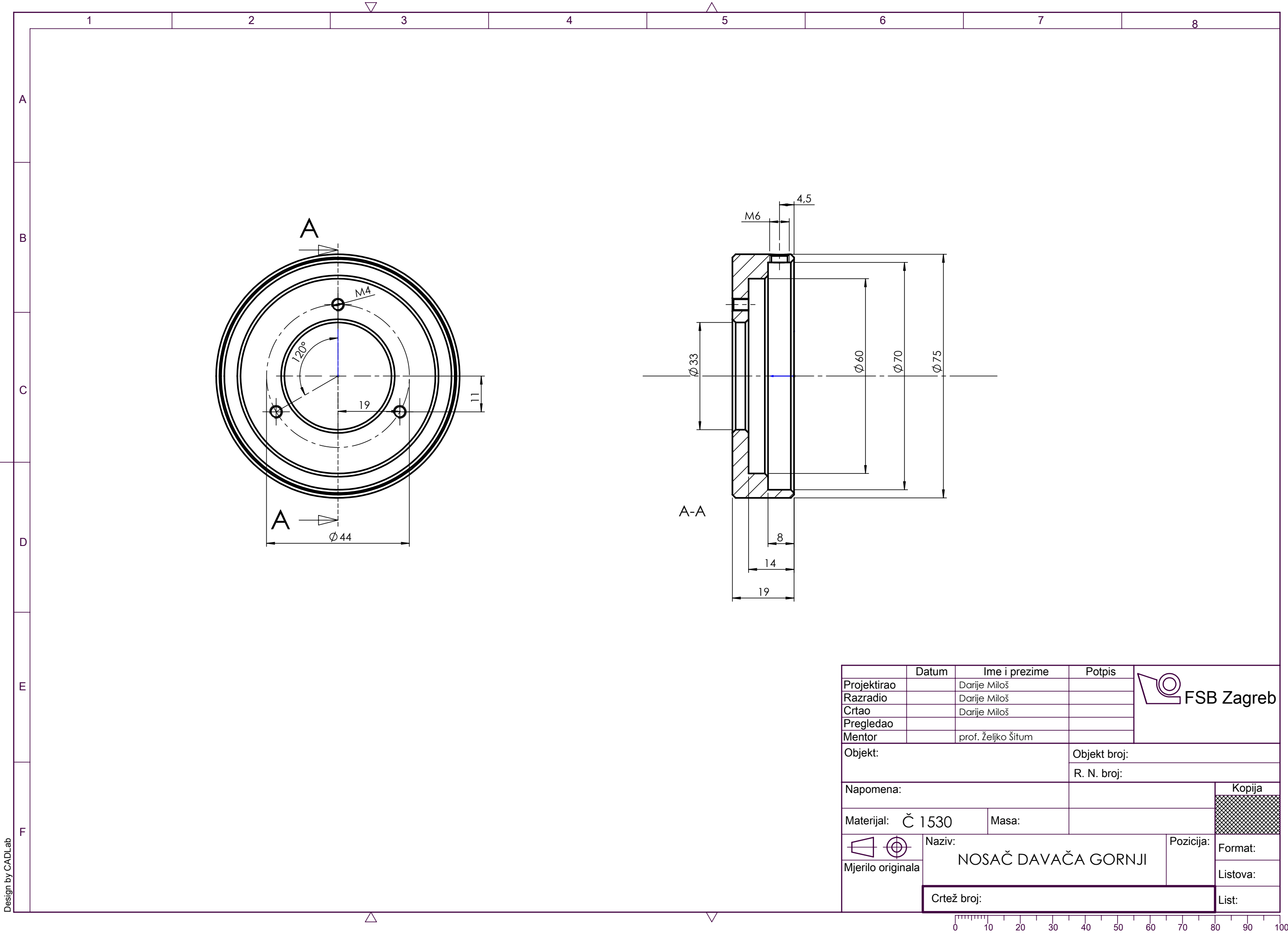
KLIZNA ČAHURA GORNJA

Crtež broj:



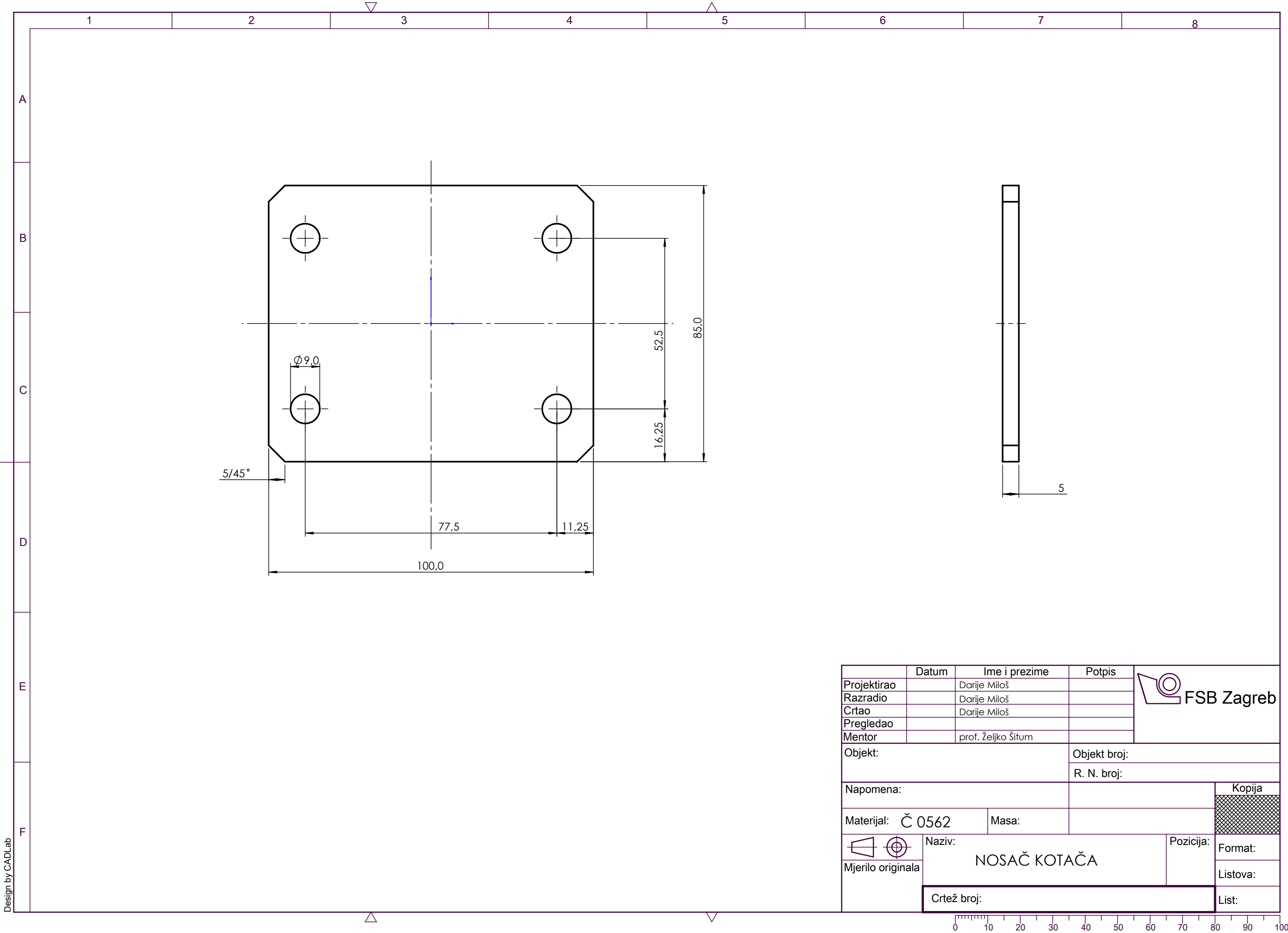
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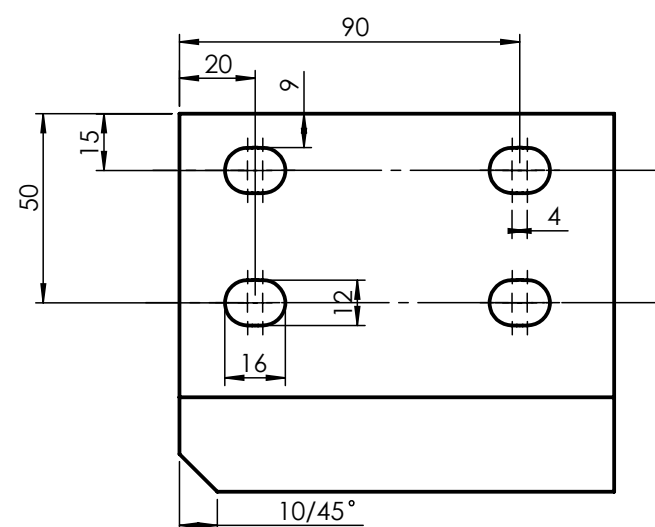
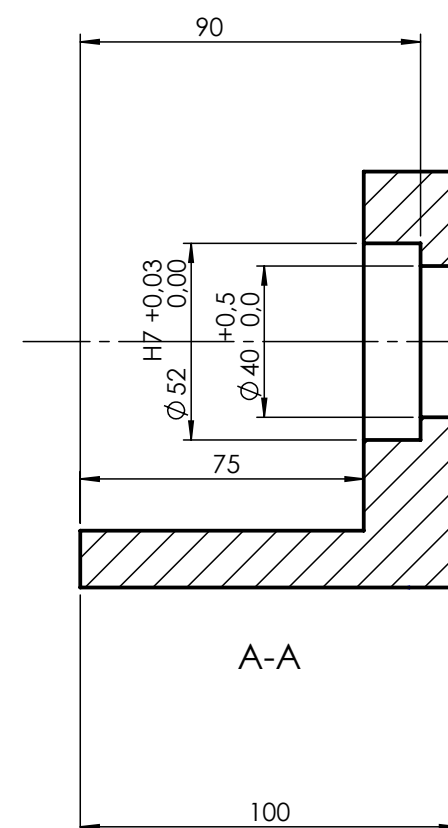







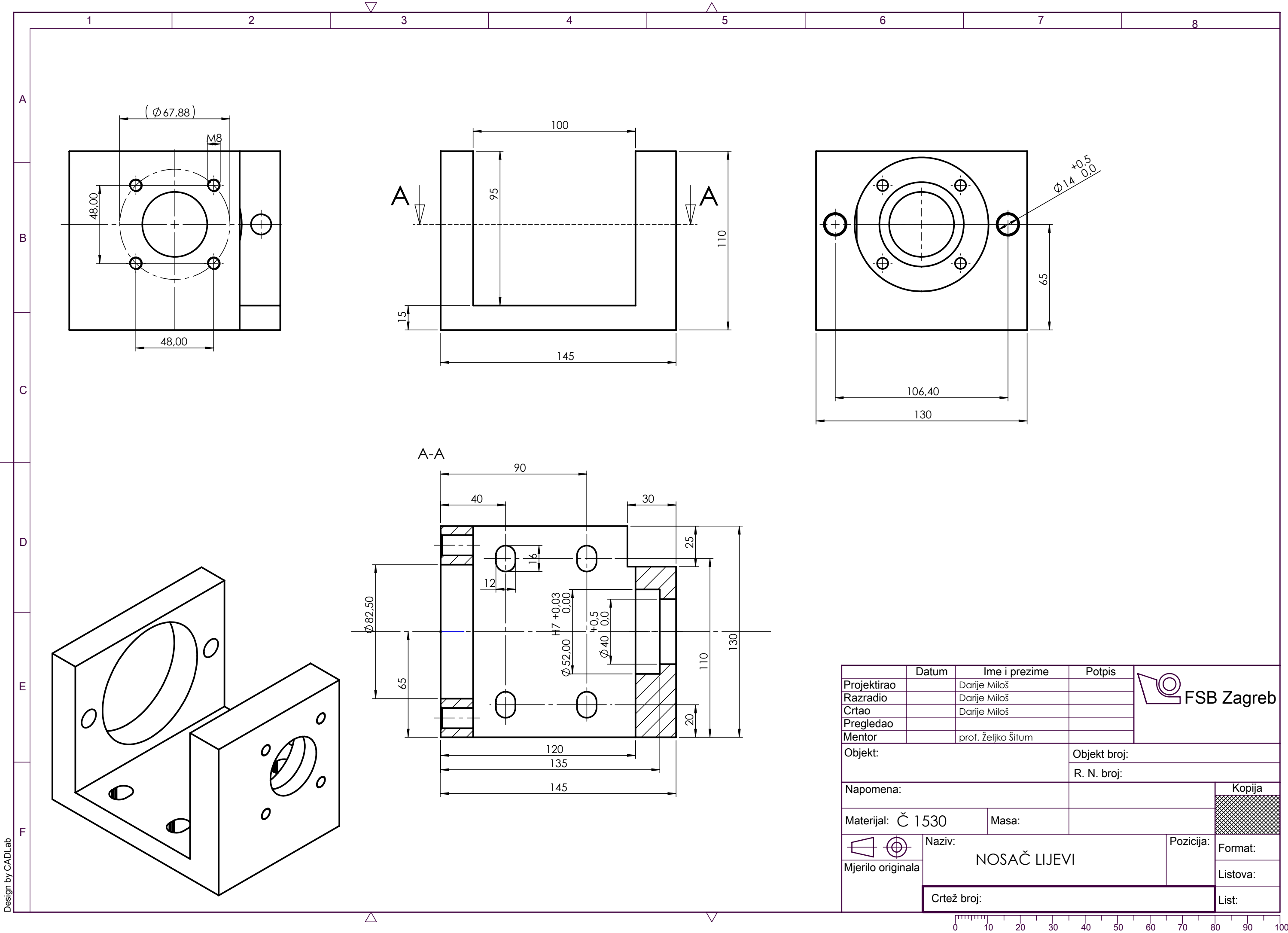
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Projektirao		Darije Miloš			
Razradio		Darije Miloš			
Crtao		Darije Miloš			
Pregledao					
Mentor		prof. Željko Šitum			
Objekt:			Objekt broj:		
			R. N. broj:		
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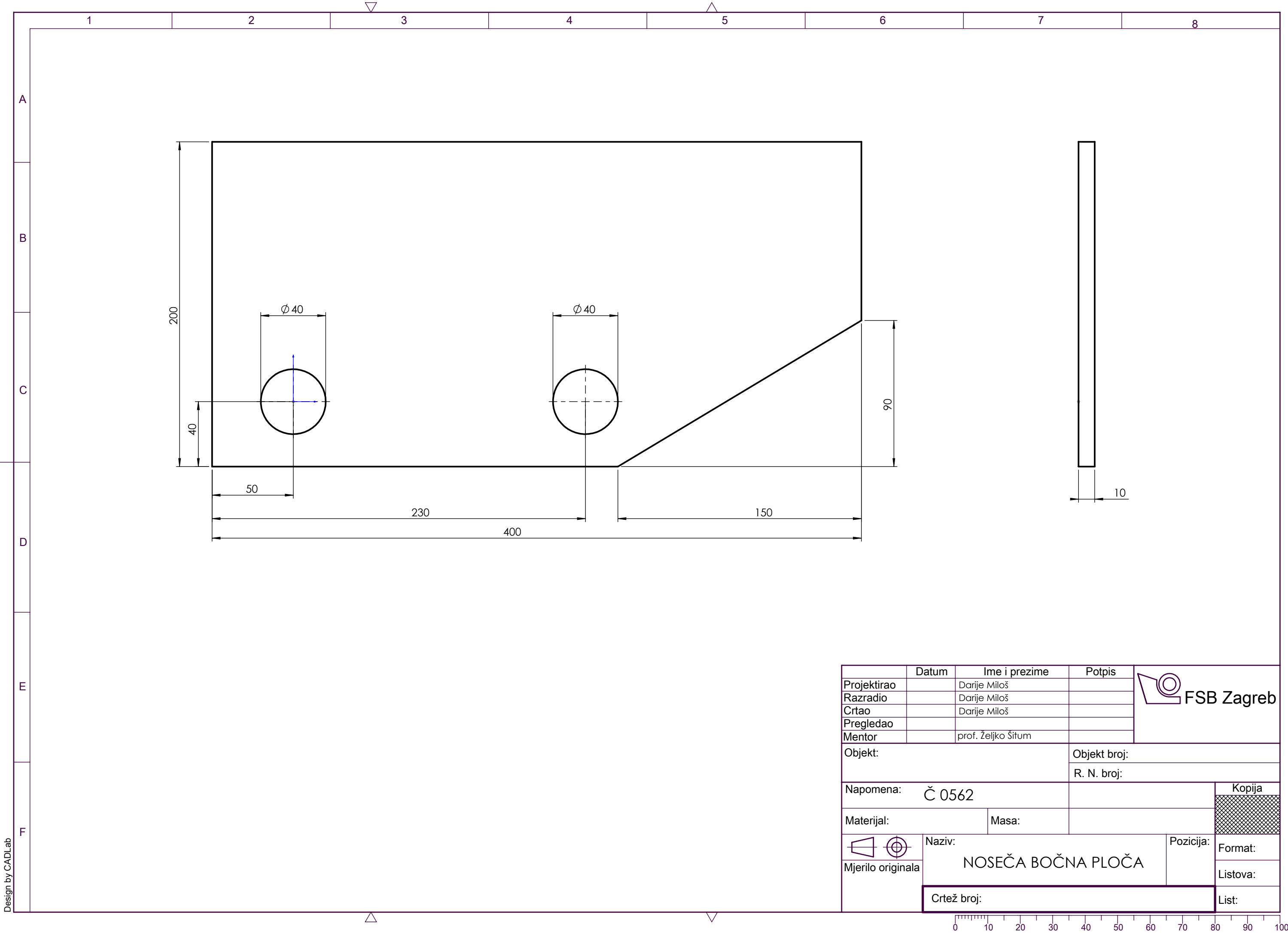
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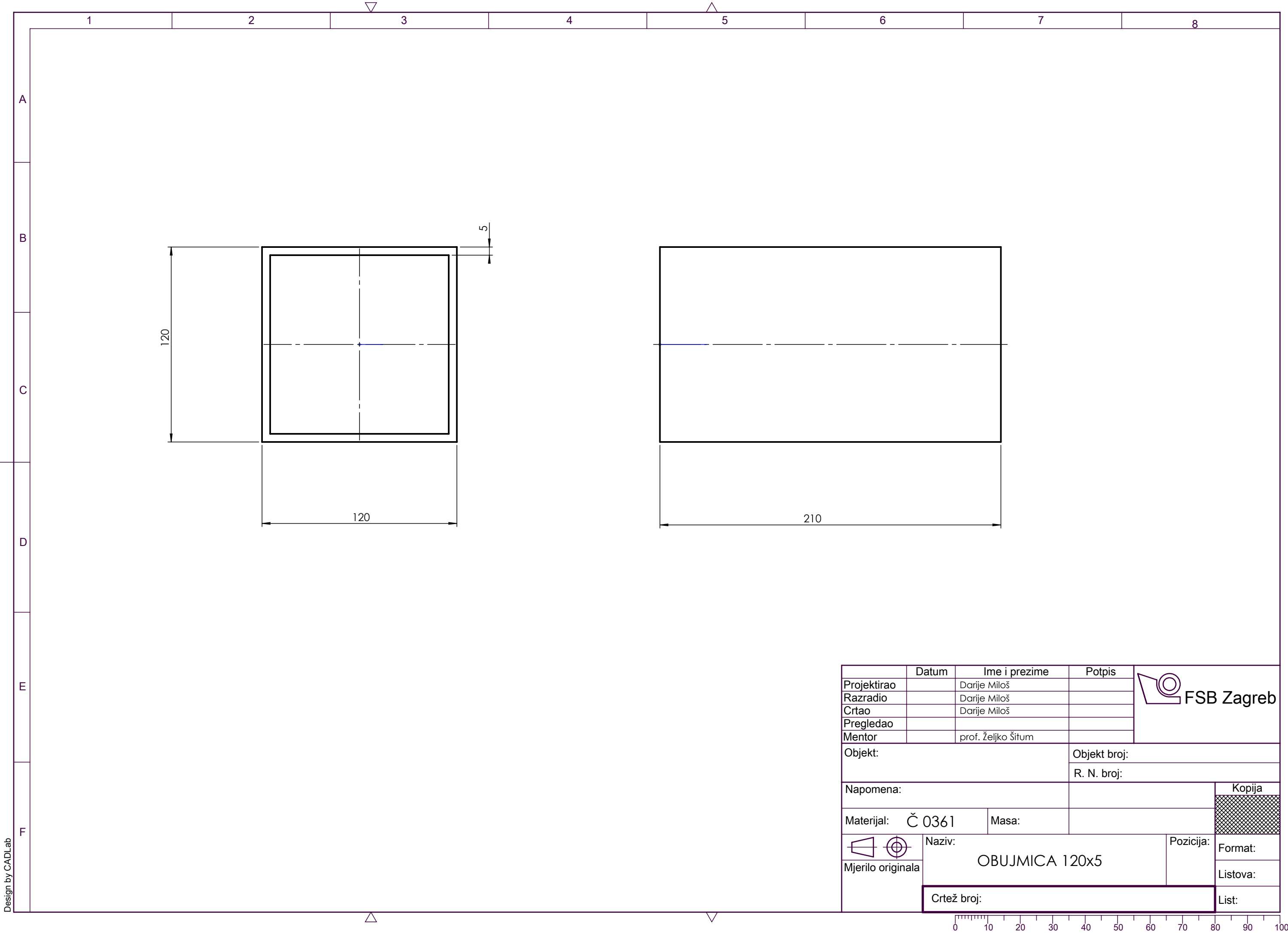
	Datum	Ime i prezime	Potpis	 FSB Zagreb
Projektirao		Darije Miloš		
Razradio		Darije Miloš		
Crtao		Darije Miloš		
Pregledao				
Mentor		prof. željko Šitum		
Objekt:			Objekt broj:	
			R. N. broj:	
Napomena:				Kopija
Materijal: Č 1530			Masa:	
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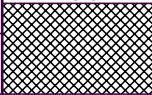





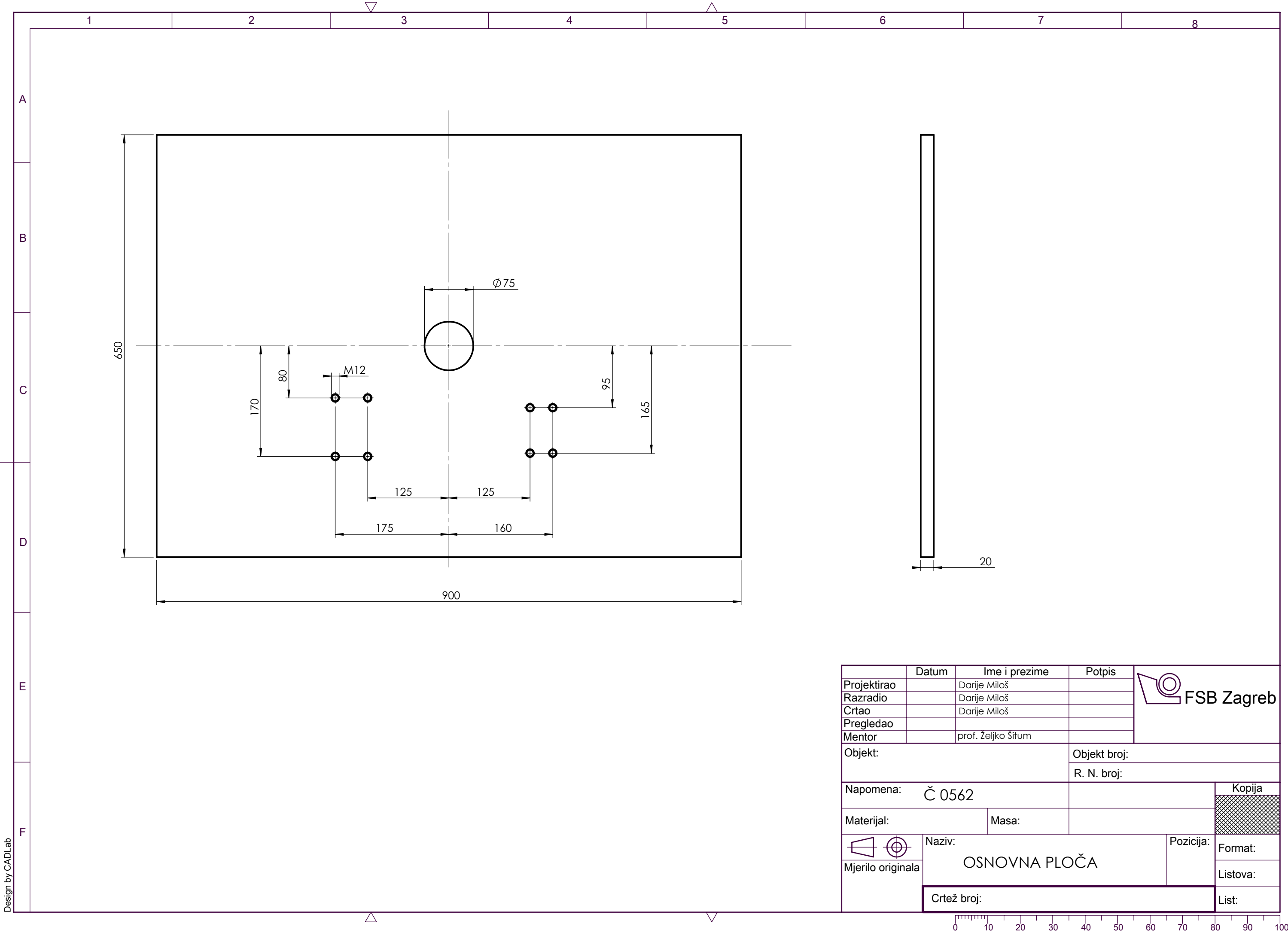
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Pregledao				
Mentor		prof. Željko Šitum		
Objekt:			Objekt broj:	
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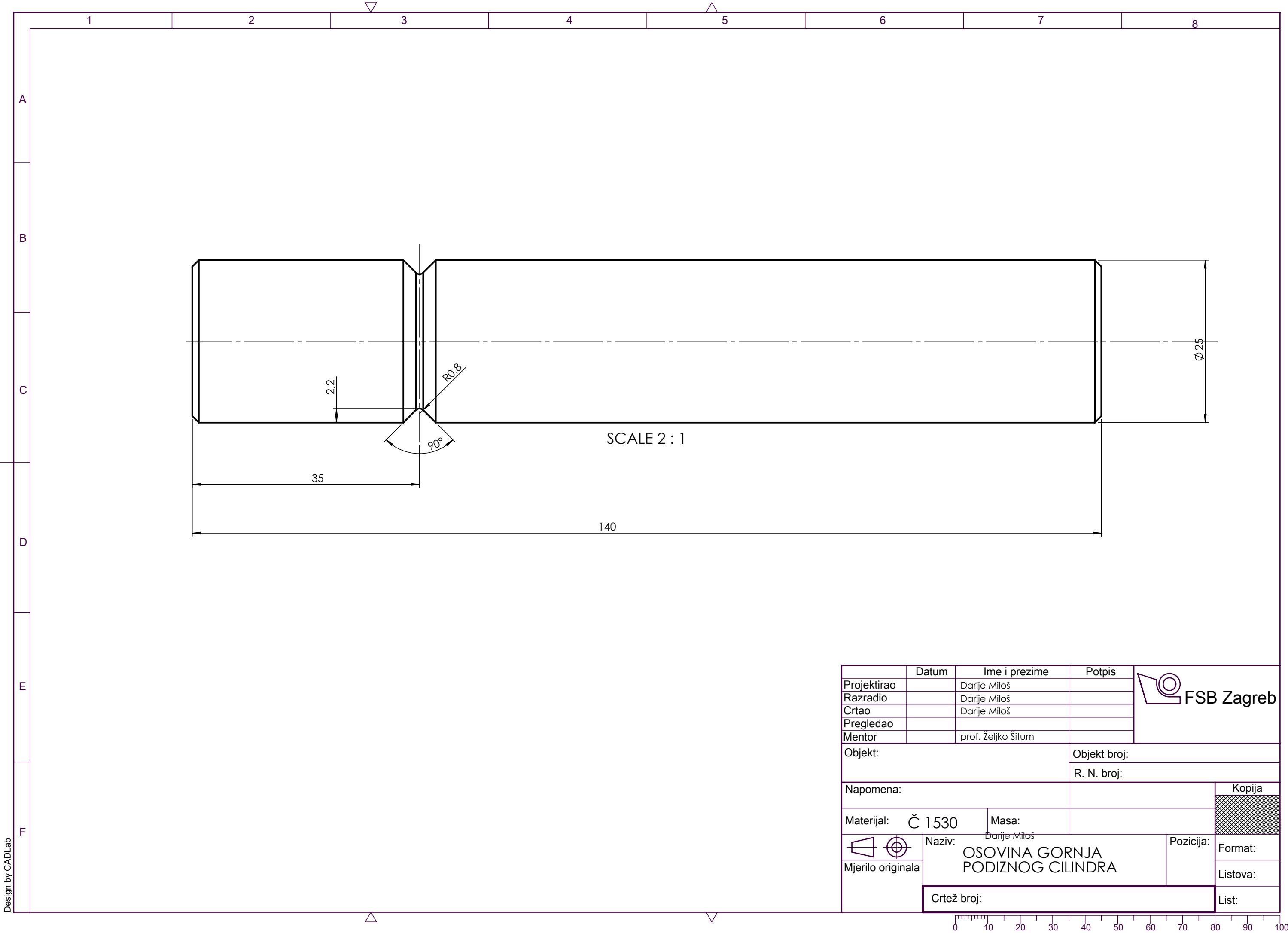


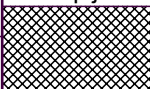


	Datum	Ime i prezime	Potpis	 FSB Zagreb	
Projektirao		Darije Miloš			
Razradio		Darije Miloš			
Crtao		Darije Miloš			
Pregledao					
Mentor		prof. Željko Šitum			
Objekt:		Objekt broj:			
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Napomena:				Kopija	
Materijal: Č 0361		Masa:			
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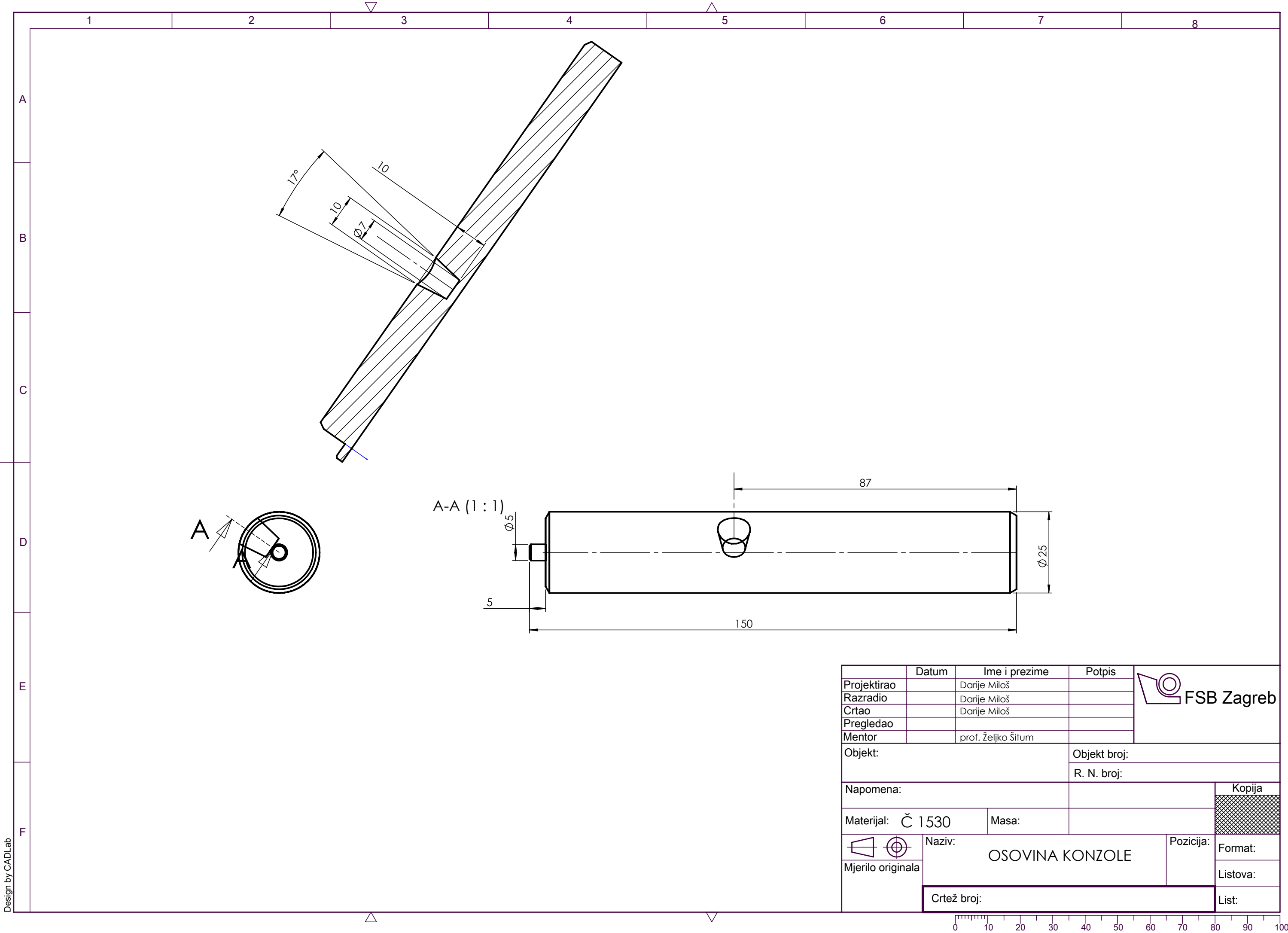


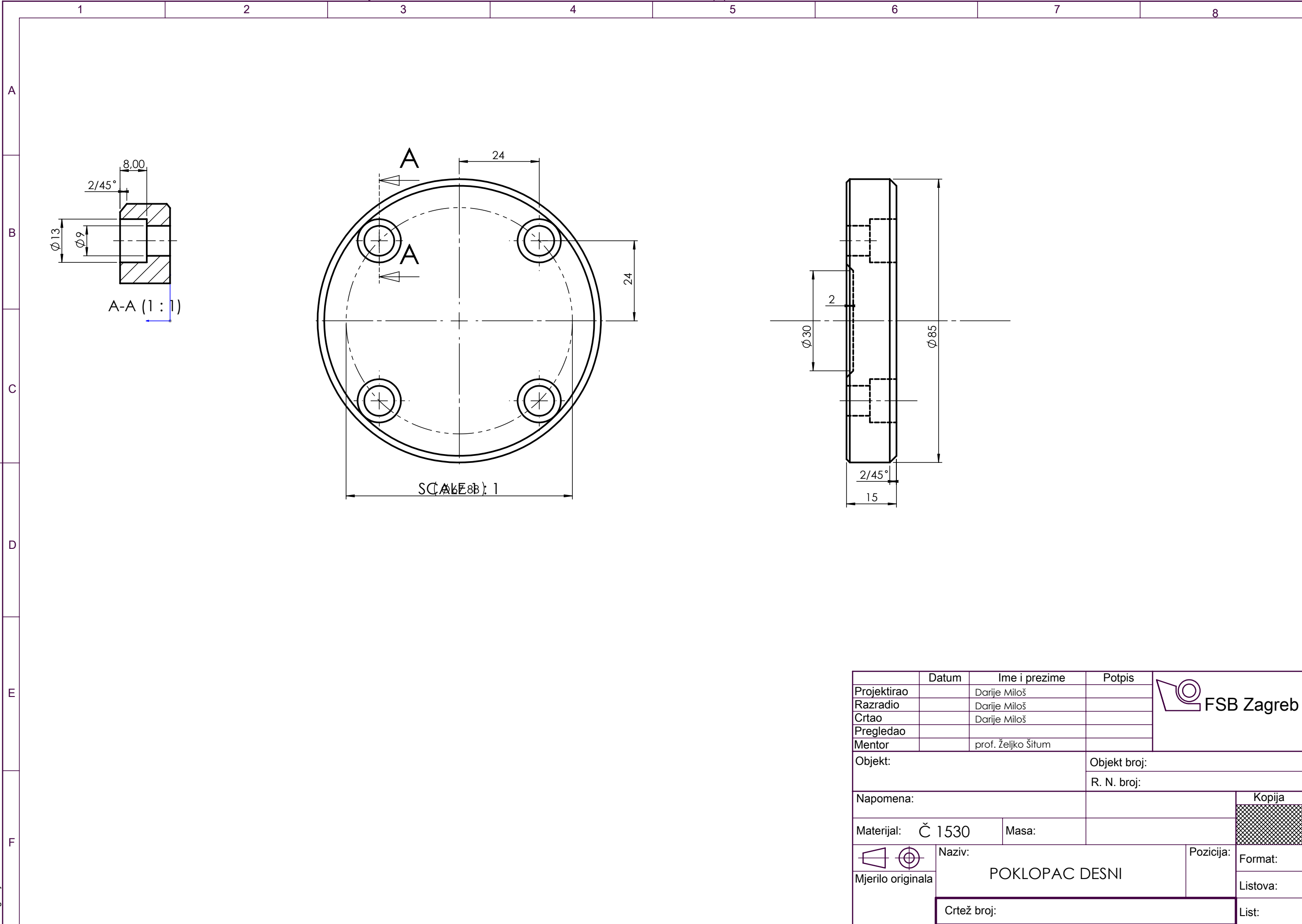


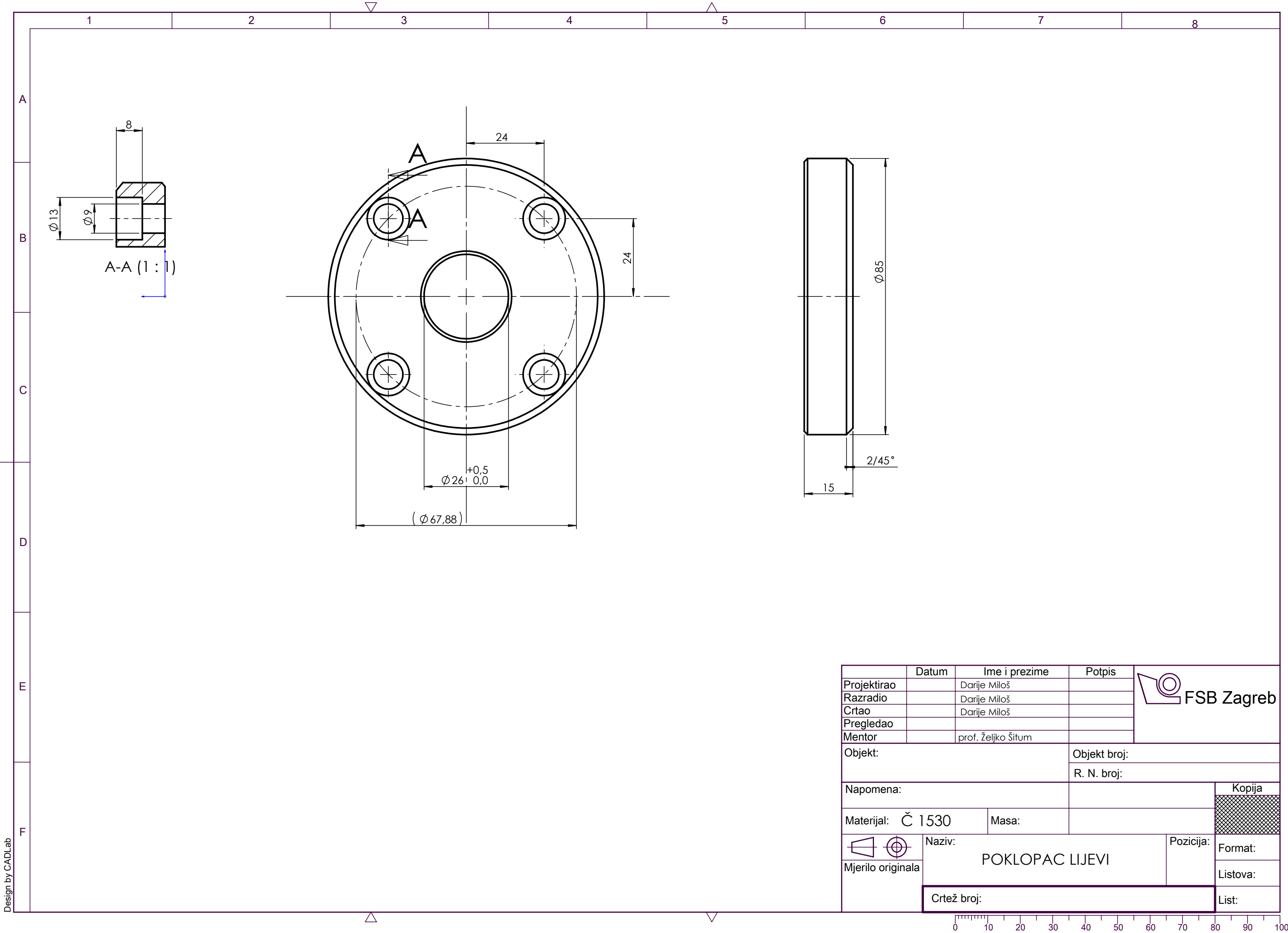


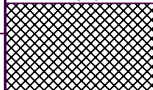

	Datum	Ime i prezime	Potpis	<div> FSB Zagreb</div>	
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Crtao		Darije Miloš			
Pregledao					
Mentor		prof. Željko Šitum			
Objekt:			Objekt broj:		
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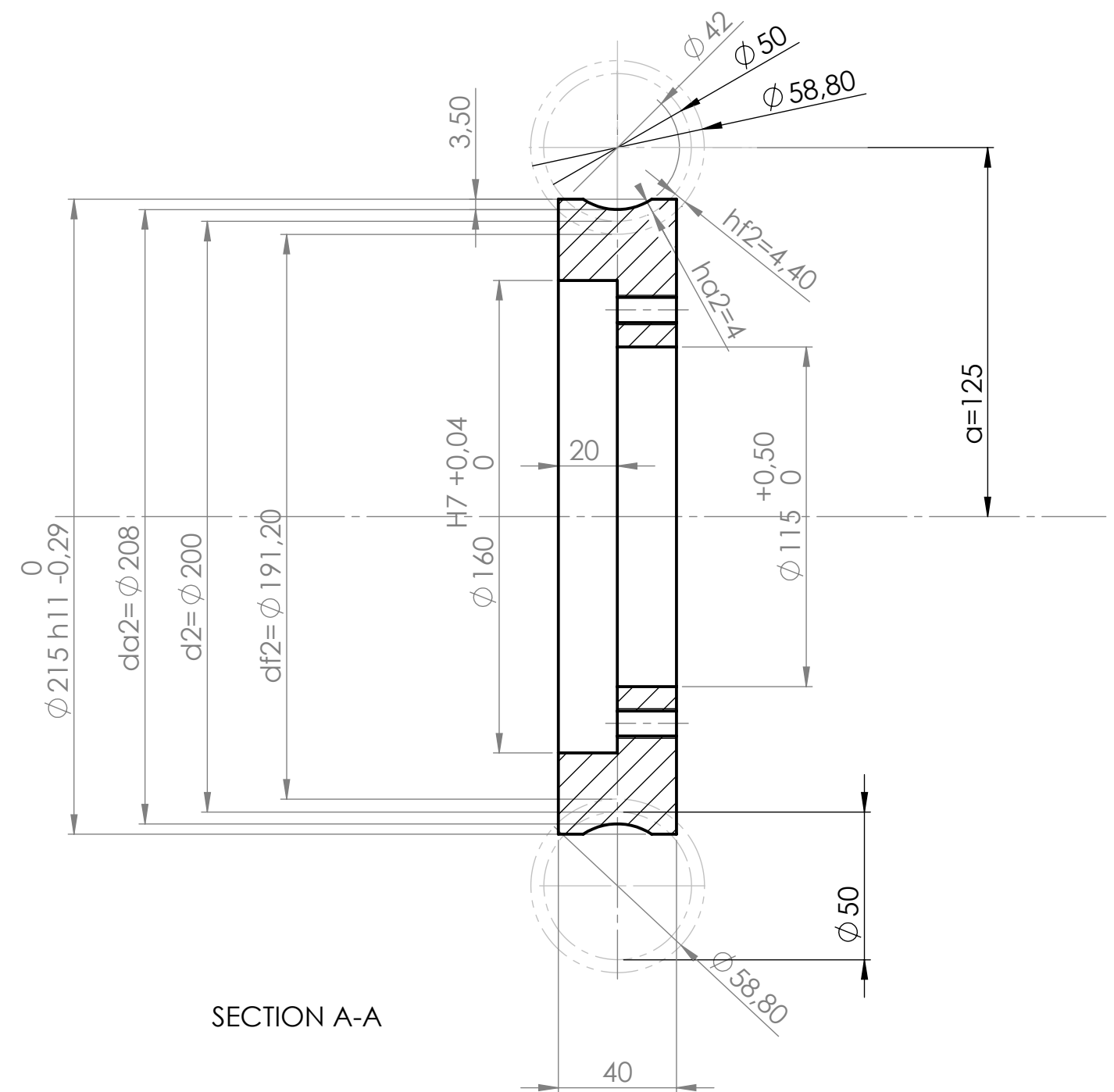






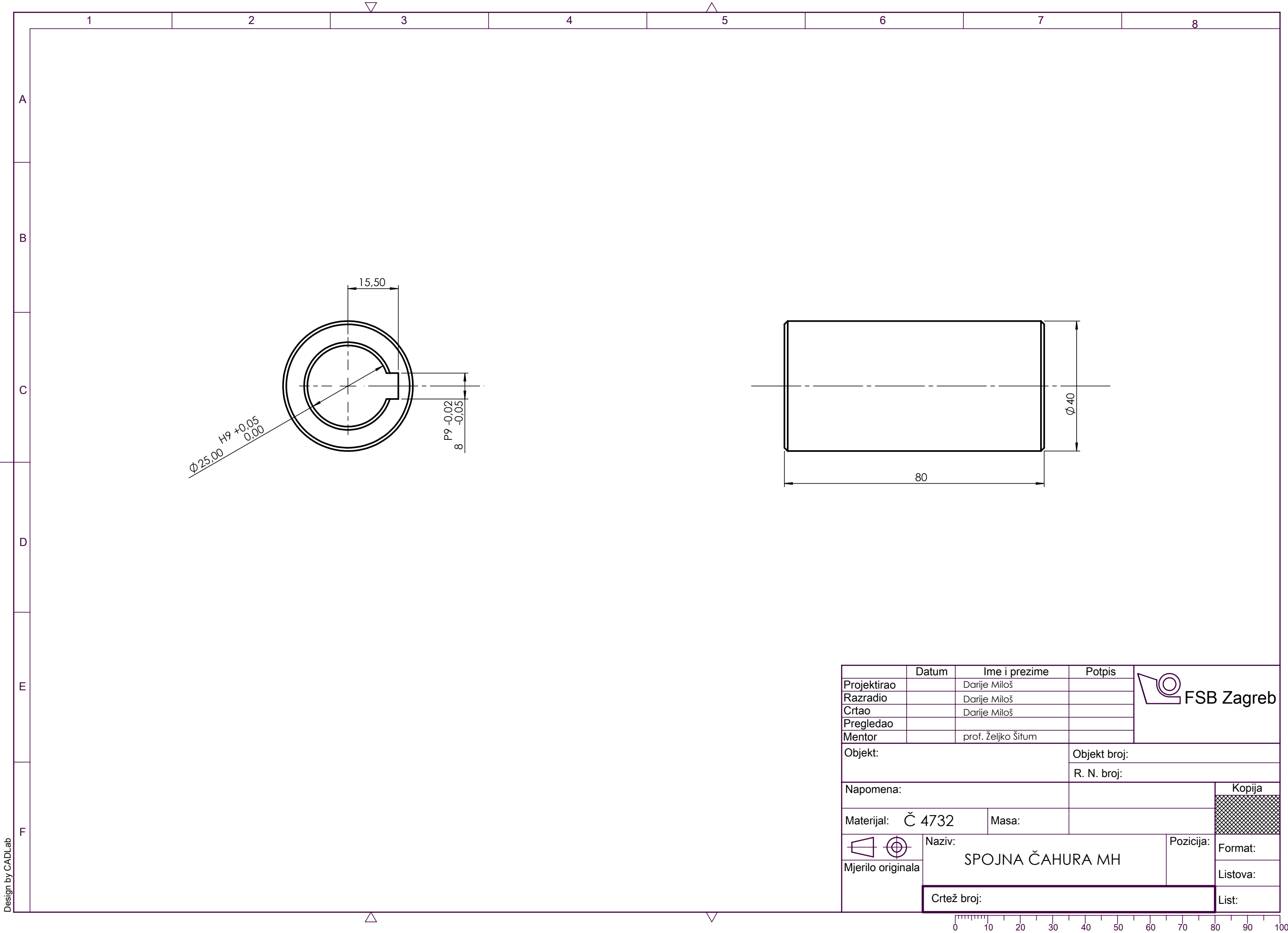
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Projektirao		Darije Miloš			
Razradio		Darije Miloš			
Crtao		Darije Miloš			
Pregledao					
Mentor		prof. Željko Šitum			
Objekt:			Objekt broj:		
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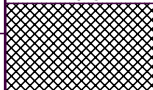

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:				FINISH:		DEBUR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
DRAWN		NAME		SIGNATURE		DATE		TITLE:			
CHK'D											
APP'VD											
MFG											
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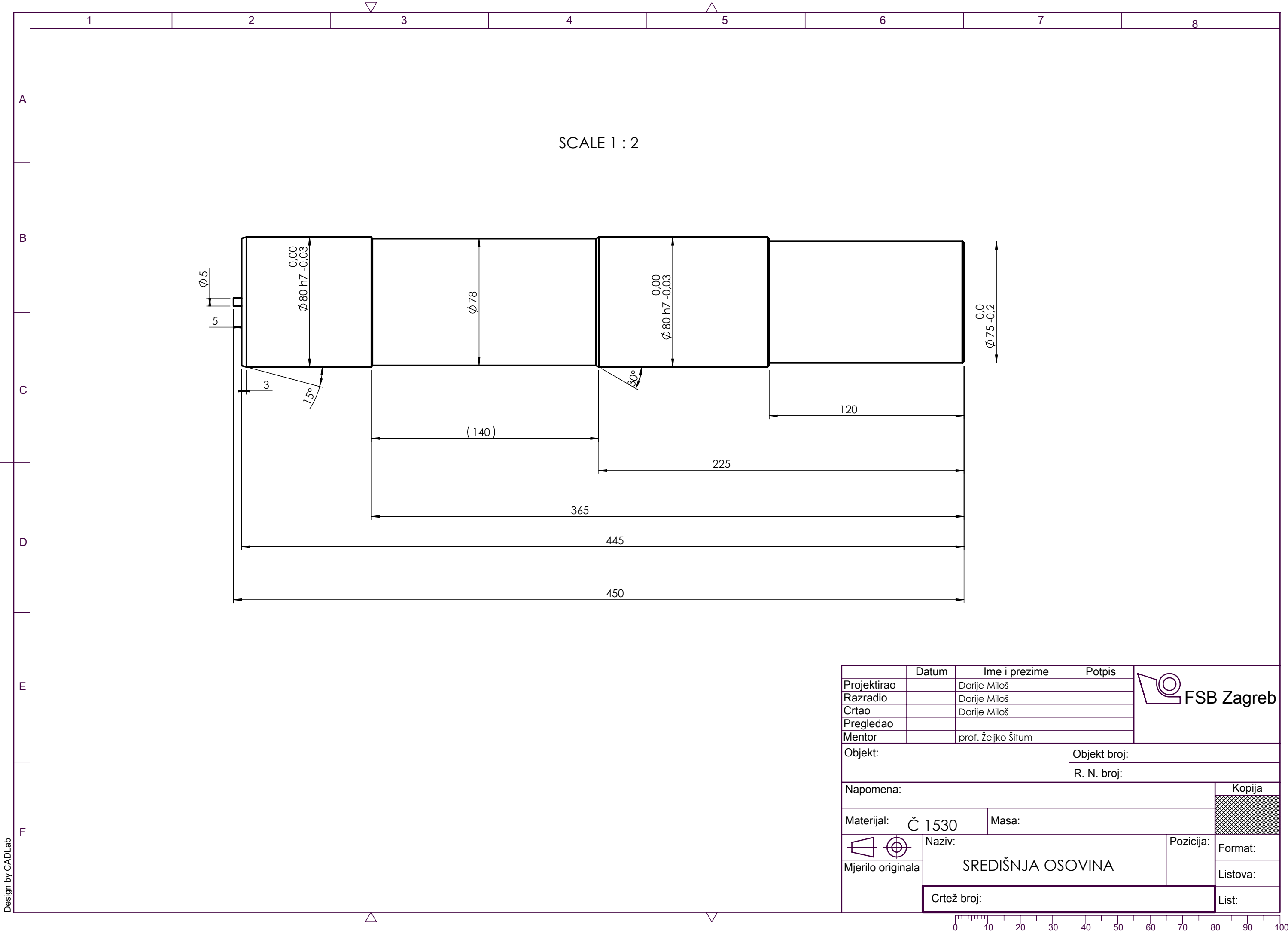
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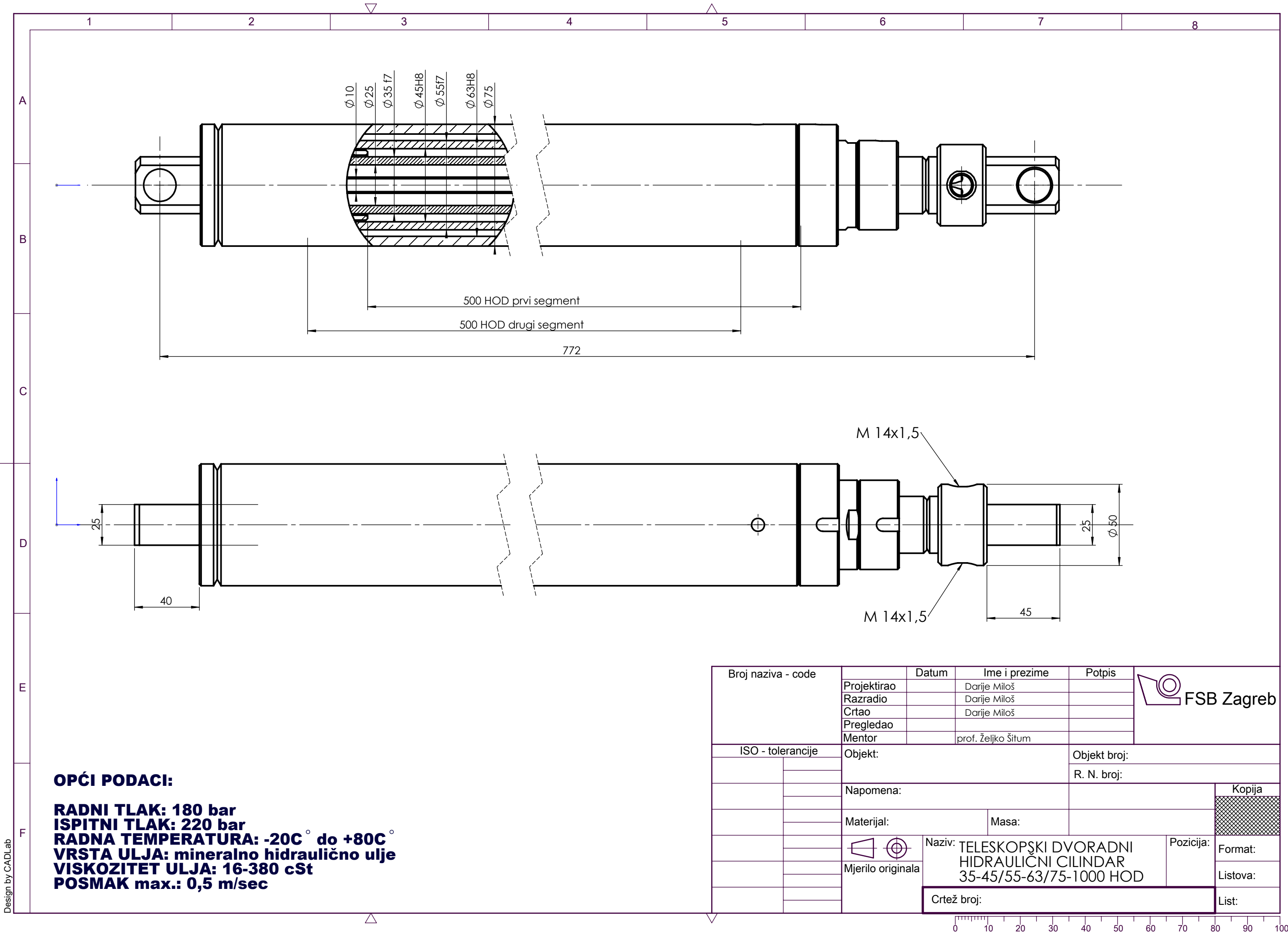
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:				FINISH:				DEBUR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
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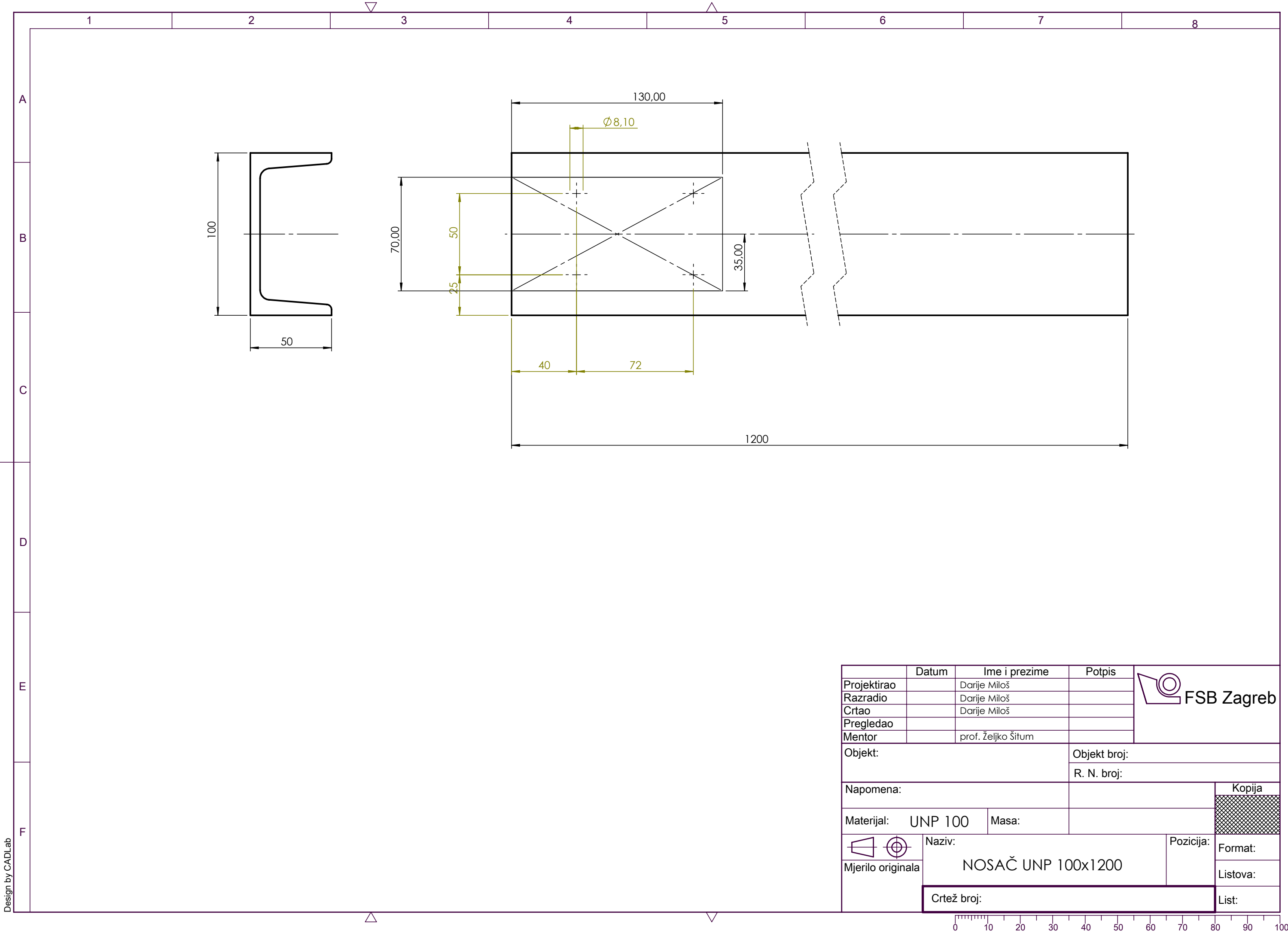





	Datum	Ime i prezime	Potpis	<div> FSB Zagreb</div>		
Projektirao		Darije Miloš				
Razradio		Darije Miloš				
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Pregledao						
Mentor		prof. Željko Šitum				
Objekt:			Objekt broj:			
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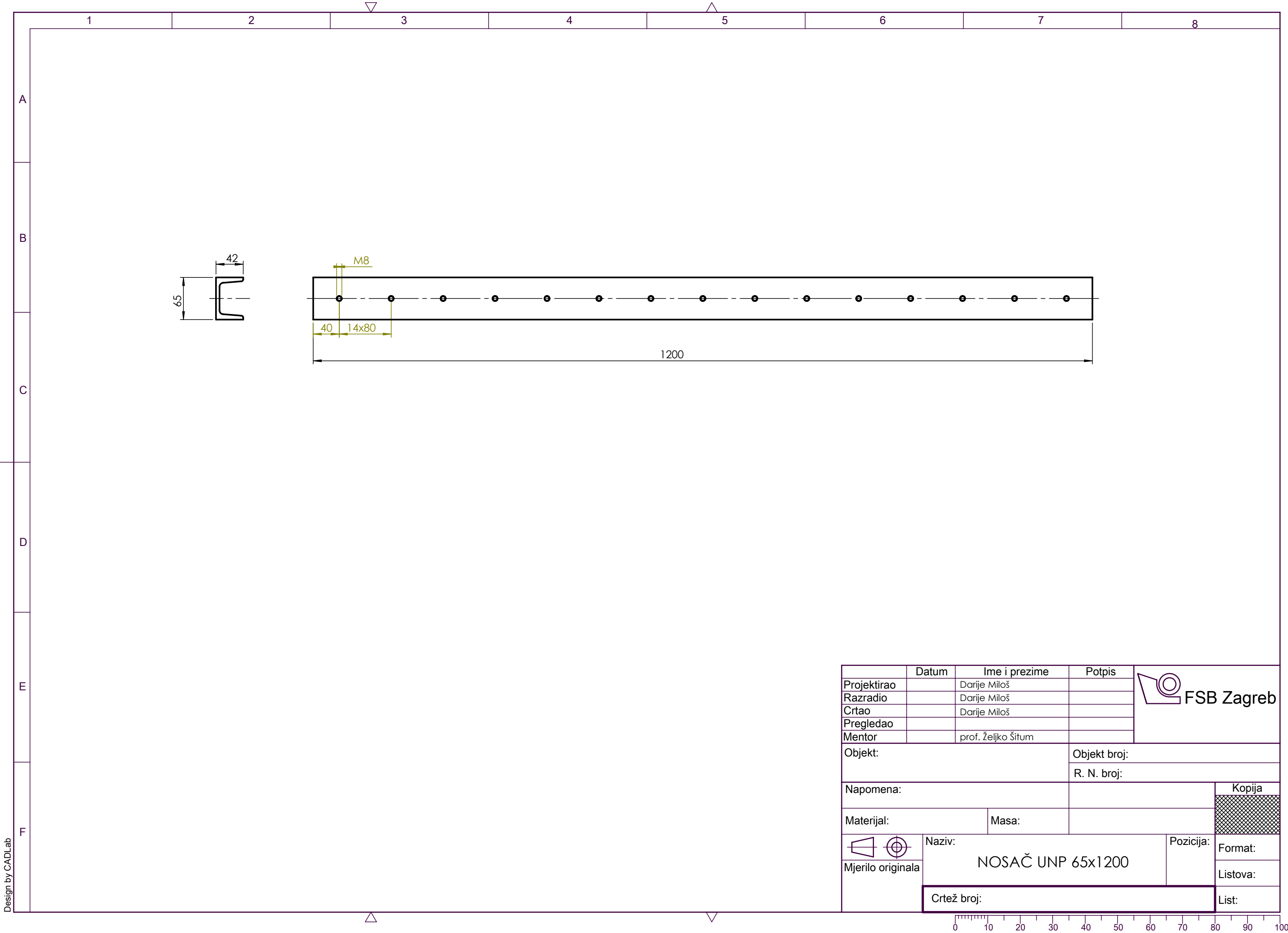








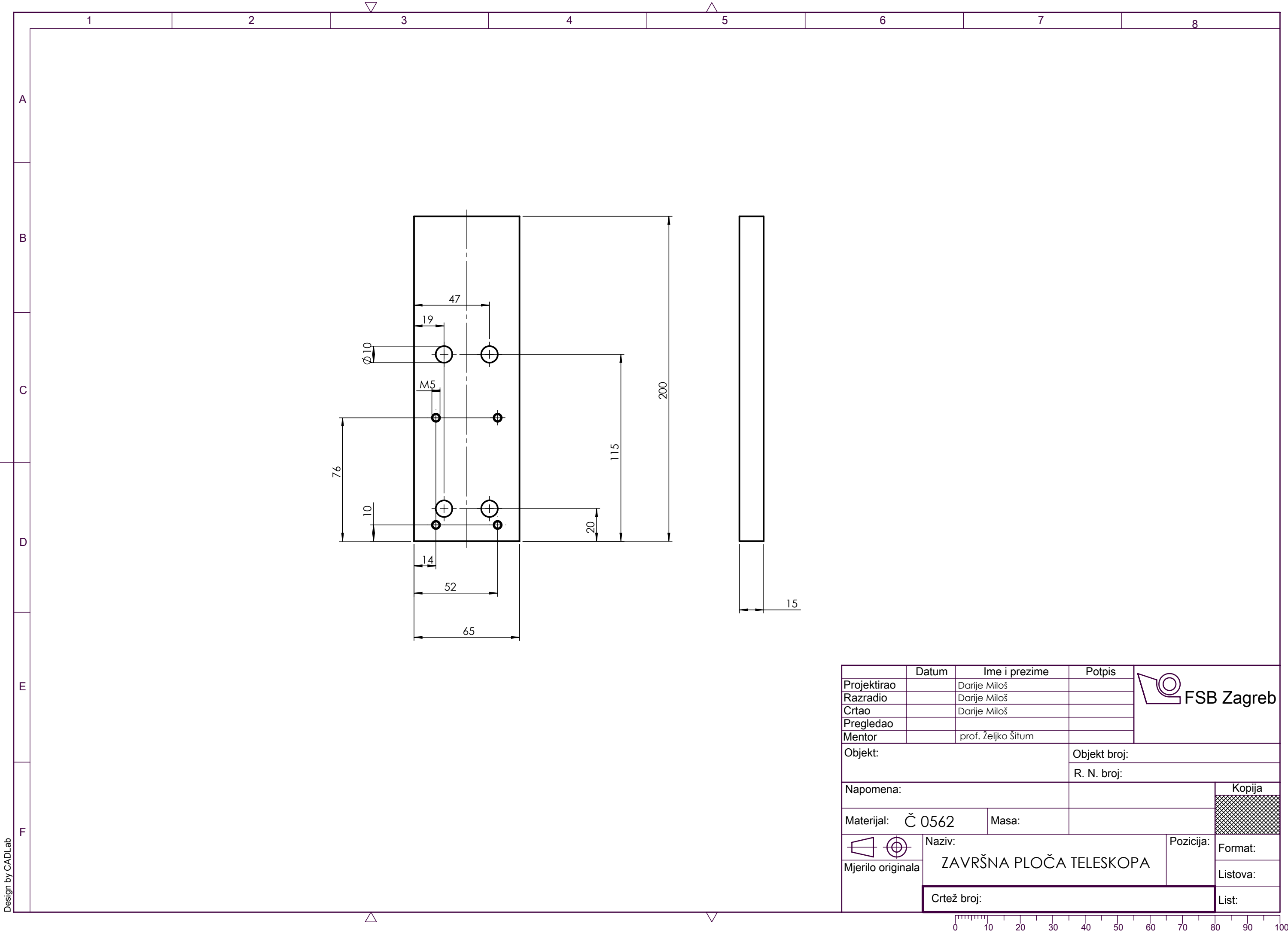


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Projektirao		Darije Miloš		
Razradio		Darije Miloš		
Crtao		Darije Miloš		
Pregledao				
Mentor		prof. Željko Šitum		
Objekt:			Objekt broj:	
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Crtao		Darije Miloš			
Pregledao					
Mentor		prof. Željko Šitum			
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Razradio		Darije Miloš			
Crtao		Darije Miloš			
Pregledao					
Mentor		prof. Željko Šitum			
Objekt:			Objekt broj:		
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